BBC

SEE SATURN'S RINGS BEFORE THEY TILT AWAY

#219 AUGUST 2023

Sky at Night

THE UK'S BEST-SELLING ASTRONOMY MAGAZINE

Prime time for the PERSEIDS

Why summer's best meteor shower promises a spectacular display

SUPER BLUE MOON

See two perigee full Moons this month Details inside

10 SIGHTS TO MAKE YOU LOVE THE MOON AGAIN

GET READY FOR THE U.S. SOLAR ECLIPSES

THE WILDEST WEATHER IN THE SOLAR SYSTEM

ACTIVITY ON THE SUN: IS THE BEST YET TO COME?

IOPTRON'S COMPACT GO-TO MOUNT ON TEST

Welcome

Get out under dark skies for the Perseids this month!

The Perseid meteor shower happens at the same time each year, as planet Earth encounters the dust left in the wake of comet 109P/Swift–Tuttle at the same point in its orbit around the Sun. But how many shooting stars we see depends on one major factor: the Moon. Some years (like last year) a bright Moon washes out all but the brightest meteors. But not this year. This year, the Moon will be a slim, waxing crescent and the sky gloriously dark on the night of 12–13 August, when the Perseids will be at their strongest. It promises to be a great display; make the most of it with the advice of meteor-watcher Paul Abel on **page 28**.

Perhaps it's because it washes out fainter meteors and deep-sky objects that some amateur astronomers have a dim view of our Moon, but there are many enthralling lunar sights to train a telescope on. On **page 60**, Stuart Atkinson picks 10 that are a little less familiar, to help us rekindle our appreciation of our nearest celestial neighbour.

Later this month, on the 27th, Saturn reaches opposition when it'll be at its brightest and best-placed for the year, visible all night. Take this opportunity to see its wonderful rings – over the next two years they will disappear as they become increasingly edge-on. Turn to Jane Clark's feature on **page 34** for advice on capturing your first image of them; hopefully it will sustain you until the ring angle improves from 2026 onwards.

Enjoy the issue!

Chris Bramley, Editor

PS Our next issue goes on sale on Thursday 10 August.

HOW TO CONTACT US

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Editorial enquiries +44 (0)117 300 8754
9:30am–5:30pm, Mon–Fri
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Sky at Night – lots of ways to enjoy the night sky...

Television
Find out what *The Sky at Night* team have been exploring in recent and past episodes on page 18

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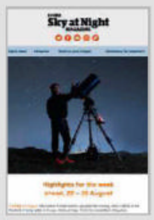

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C = on the cover

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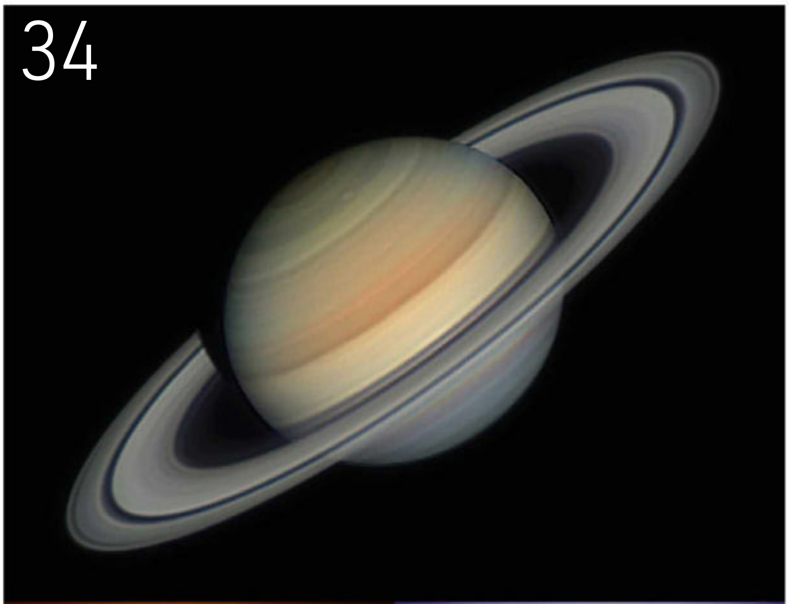
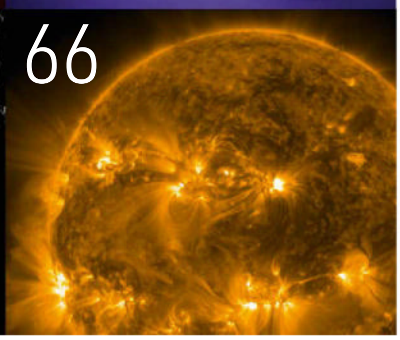
New to astronomy?

To get started, check out our guides and glossary at **www.skyatnightmagazine.com/astronomy-for-beginners**





This month's contributors

Paul Abel

Astronomer

"The Perseid meteor shower peaks on the 12th this month – and with the Moon out of the way it should be an excellent opportunity to observe them!" **Get ready for summer's strongest meteor shower, page 28**

Jane Clark

Astrophotographer

"Planetary photography can be a fun challenge, but getting started needn't be intimidating." **Jane shows you the kit, techniques and software you need to capture Saturn's rings before they vanish from view, page 34**

Mary McIntyre

Outreach astronomer

"Meteor impacts were an important part of our Solar System's evolution, and recreating them can help bring the process to life." **Don't miss Mary's fun (and messy!) Moon crater activity on page 74**

Extra content ONLINE

Visit **www.skyatnightmagazine.com/bonus-content/YG8K5WQ** to access this month's selection of exclusive Bonus Content

AUGUST HIGHLIGHTS

Interview: Making spaceflight global

Mishaal Ashemimry from the Saudi Space Commission on growing the space industry across the globe.

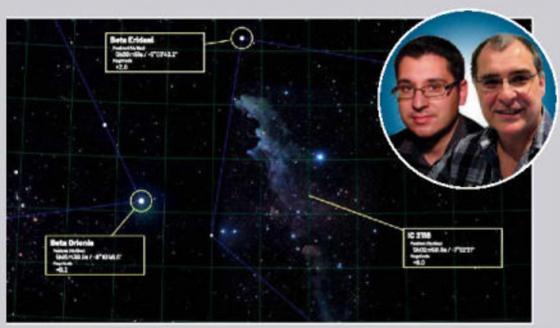
The Sky at Night – The UK Space Race

Watch this episode of *The Sky at Night*, in which Maggie and Chris learn about the UK firms launching into space.

Download a meteor observing form

Use this to record your observations of meteor showers. See **page 28** for a complete guide to this month's Perseids.

The Virtual Planetarium



Pete Lawrence and Paul Abel guide us through the best sights to see in the night sky this month.

CURIOSITY LOOKS BACK

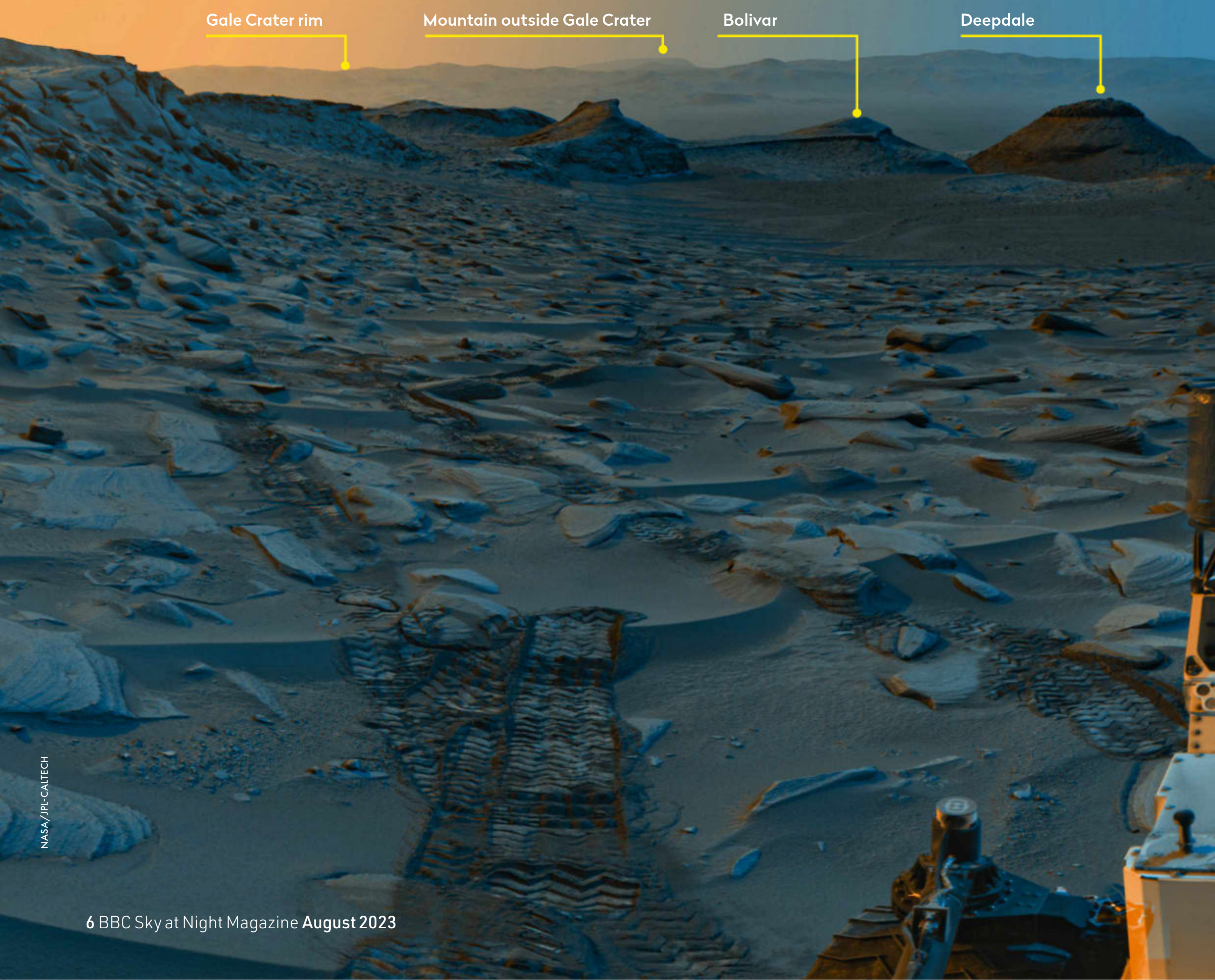
The NASA rover sends back its latest postcard from Mars

CURIOSITY ROVER, 13 JUNE 2023

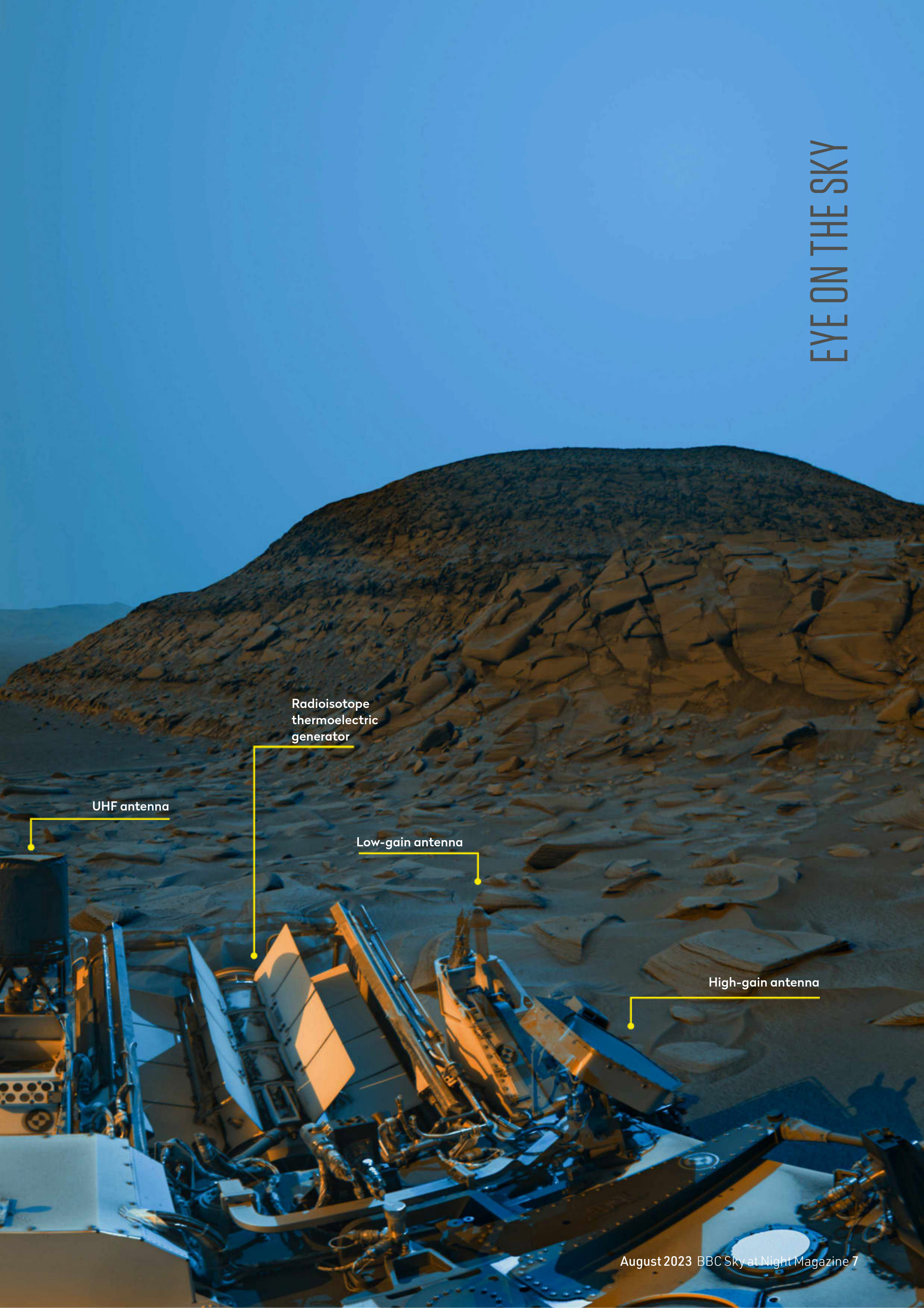
This picture of the Marker Band Valley on Mars was created by combining two panoramic shots of the region – one taken in the morning and one in the evening – and then adding colour. Each panorama was in turn constructed from five individual images taken by Curiosity's black and white navigation cameras.

It's likely that this winding area is the site of an ancient lake, unexpectedly discovered by the rover. Visible in the picture are the hills Bolivar and Deepdale, which Curiosity recently drove between, along with several other small hills, all of which lie within Gale Crater. The crater's rim can be seen 40km away, while the peak of an 87km-distant mountain is just visible beyond. Also visible are Curiosity's tracks, along with its three antennae and its radioisotope thermoelectric generator.

MORE ONLINE
Explore a gallery of these and more stunning space images



NASA/JPL-CALTECH


Radioisotope thermoelectric generator
UHF antenna
Low-gain antenna
High-gain antenna

△ Star-studded cluster

HUBBLE SPACE TELESCOPE, 19 JUNE 2023

NGC 6544, lying in the constellation of Sagittarius, is one of the smallest known globular clusters – but as this new picture shows, that certainly doesn't mean it's lacking in stars. The image was created using data from Hubble's Advanced Camera for Surveys and Wide Field Camera 3, which have been searching in visible light for evidence of a pulsar recently observed at other wavelengths.

ESA/HUBBLE & NASA/W. LEWIN/F. R. FERRARO, NASA/JPL-CALTECH/SWRI/MSSS/IMAGE PROCESSING BY KEVIN M. GILL, ESA/HUBBLE & NASA/M. GULLIEUSZIK AND THE GASP TEAM, ESO/VPHAS+TEAM

Lightning strike ▷

JUNO PROBE, 15 JUNE 2023

On Earth, lightning is most prevalent towards the equator, but on Jupiter it's the poles that see all the action. This image showing a lightning flash close to the planet's north pole was captured by the JunoCam instrument on NASA's Juno probe as it orbited some 32,000km above the clouds in December 2020, but has just been released after being processed by citizen scientist Kevin M Gill.

Jelly on a photographic plate ▷

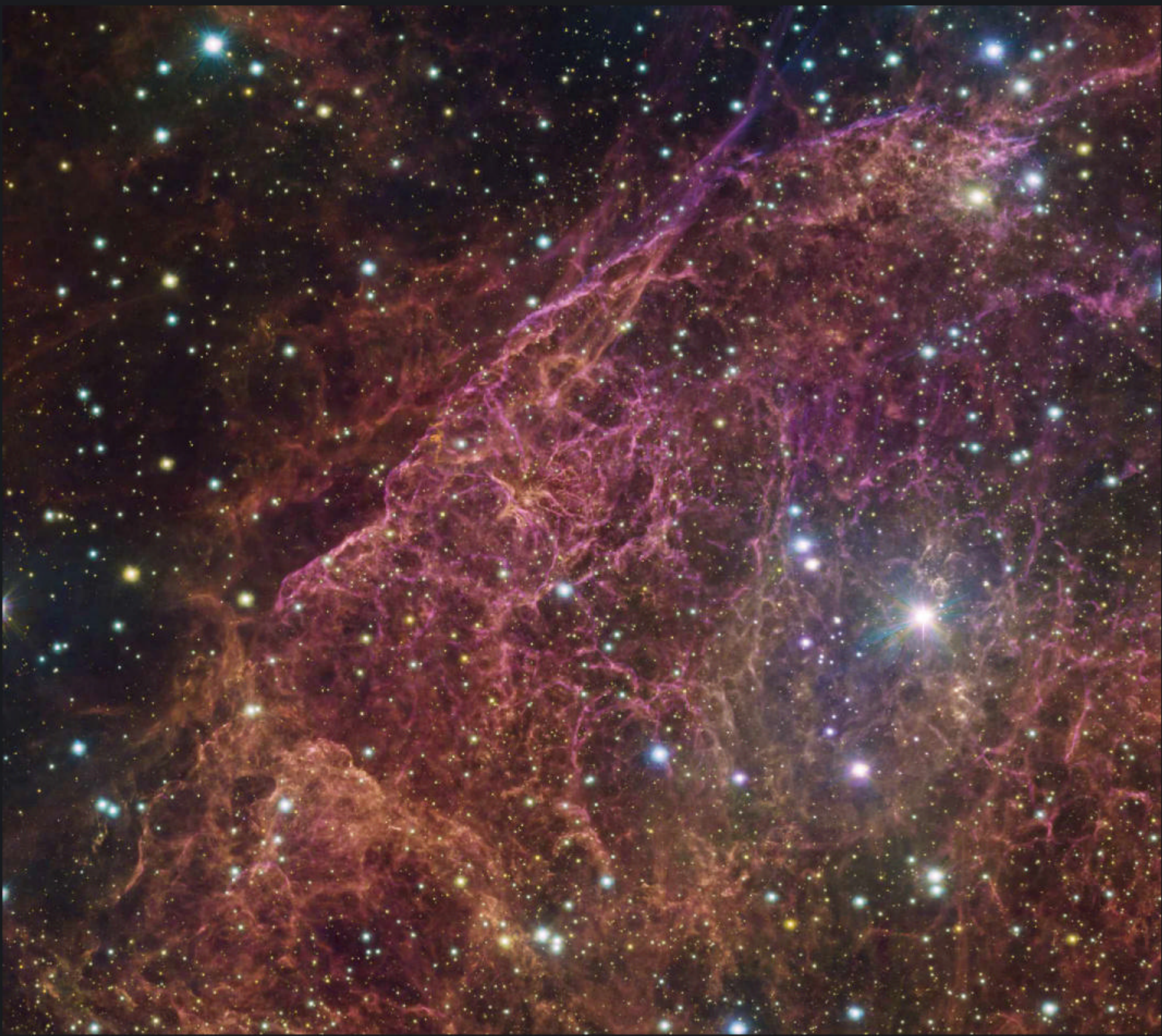
HUBBLE SPACE TELESCOPE, 22 MAY 2023

Lying some 900 million lightyears from Earth in the constellation of Coma Berenices, this is JW9, one of several 'jellyfish galaxies' Hubble has been studying lately. Their name comes from the trailing tendrils of gas that are ripped off them as they move through the dense plasma in their galaxy cluster. These tendrils become areas of intense star formation.

▽ In the pink

VLT SURVEY TELESCOPE, 29 MAY 2023

It's not the stars that are the star of the show in this image of a region in the Vela constellation. What grabs your attention instead is the giant pink cobweb of interlaced gas filaments, all that remains of a once-massive star that met its end in a supernova around 11,000 years ago. The Vela supernova remnant is one of the closest to Earth, lying just 800 lightyears away.



The latest astronomy and space news, written by Ezzy Pearson

BULLETIN

NASA/ESA/STSCI

▲ Satellites like this one photobombing the Mice Galaxies NGC 4676 will be spotted and erased more easily

Hubble edits out satellite interference

New software will remove satellite streaks from the telescope's images

The Hubble Space Telescope has been fighting an increasingly difficult battle in recent years against satellites leaving bright trails across its images, but a new piece of software could provide a valuable weapon in efforts to remove them.

When Hubble launched in 1990, there were only around 470 satellites in orbit. Today there are close to 8,000 and the number is rising fast. As the telescope sits in low-Earth orbit, many of these satellites pass above it, crossing its field of view and leaving bright streaks across its images. In 2022, around 10 per cent of Hubble images were affected by such interlopers. Fortunately, the problem only affects a small part of each image's field.

"The average width I measured for satellites was 5 to 10 pixels," says Dave Stark from the Space Telescope Science Institute. "Hubble's Advanced Camera for Surveys' widest view is 4,000 pixels across, so a typical trail will affect less than 0.5 per cent of a single exposure."

The remaining 99.5 per cent of the frame is still useable scientific data. Hubble's images are created like many other astrophotos, with multiple exposures which are then stacked together. Not only does this allow astronomers to identify satellite streaks, as they will only appear on one exposure, it also means the marks can be masked out on affected frames, so as not to affect the final images. However, some trails are very faint, meaning they're missed by current techniques.

Stark's team created a new program that uses a method called the Radon Transform, which sums the light along every straight path across an image. This makes the linear streaks of satellites clearly 'pop-out', allowing twice as many to be identified.

"We have a toolbox of things that people use to clean Hubble data and calibrate it," said Stark. "And our new application is another tool that will help us make the best out of every Hubble exposure."

www.stsci.edu

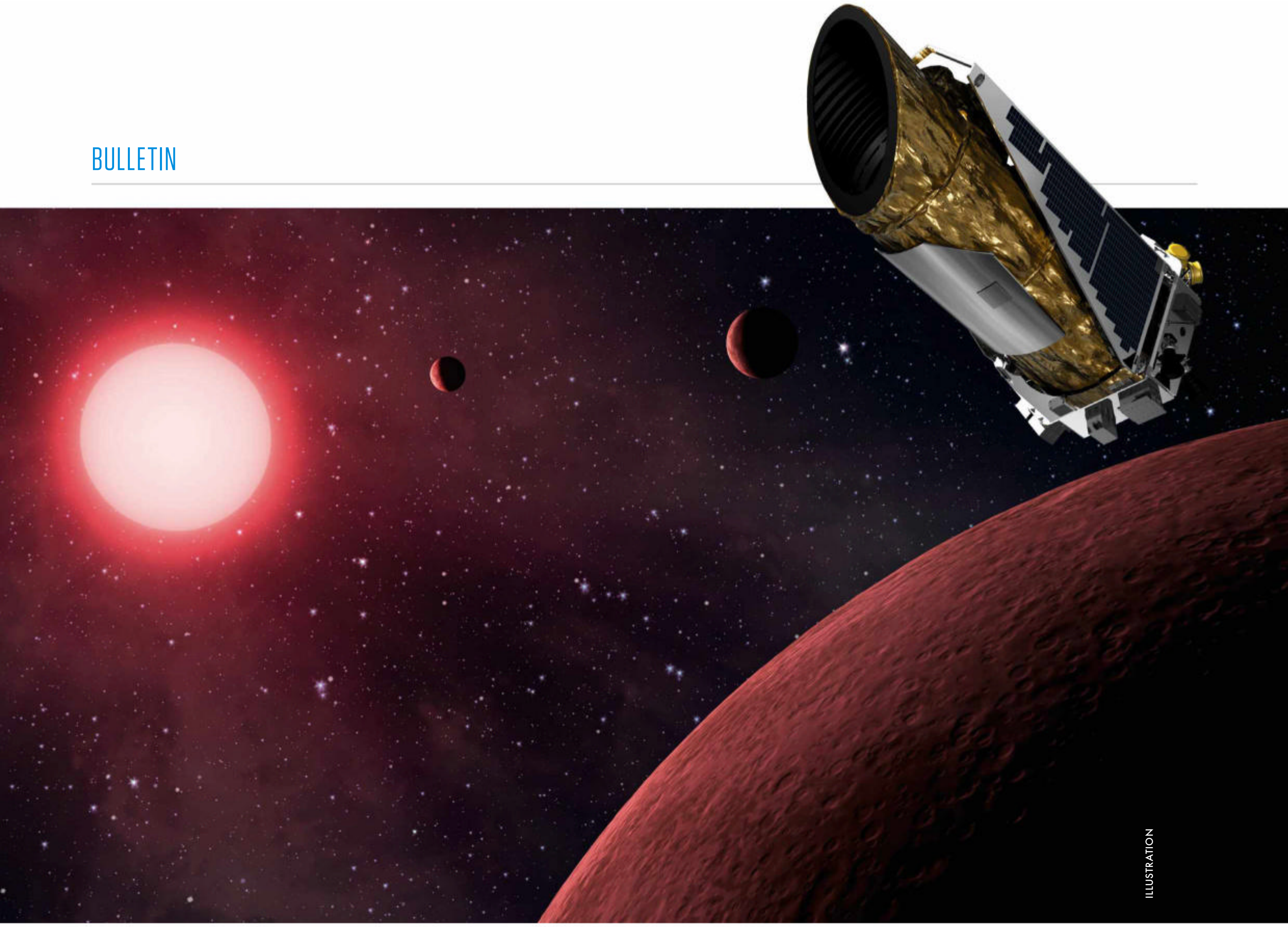
Comment

by Chris Lintott

It's great news that tools are being developed to help Hubble deal with satellite trails. But don't take from this that the menace of large satellite constellations is under control.

The truth is, while you can remove satellite streaks from the images, you can never get back the view of the sky hidden behind them. That data is lost forever. For Hubble, which mostly spends its time on long exposures of individual objects, that's not too big a deal. But ground-based telescopes, particularly those carrying out survey work, scanning the sky for objects like near-Earth asteroids, will still be badly affected, as we highlight in this month's *Sky at Night* episode (see **page 5**). Software will help, but it can't on its own save the sky.

Chris Lintott co-presents *The Sky at Night*



▲ **The planet-finding telescope died in 2018, but citizen scientists just found three missed worlds in data from its very last days**

Kepler's last planets found in archive data

The three worlds were detected when the now-defunct spacecraft was 'running on fumes'

Of the 5,000 planets beyond our Solar System discovered so far, around half were found by NASA's Kepler Space Telescope. Now astronomers believe they have identified the last three planets the telescope ever uncovered.

Kepler launched in 2009, spending four years monitoring 150,000 stars, looking for the dip in brightness caused by a planet passing in front. In May 2013, however, the second of the spacecraft's four reaction wheels – which helped keep it steady – failed. The Kepler team eventually found another way to stabilise the craft and conducted the K2 observing campaign which ran until the telescope used up its fuel, officially retiring on 30 October 2018.

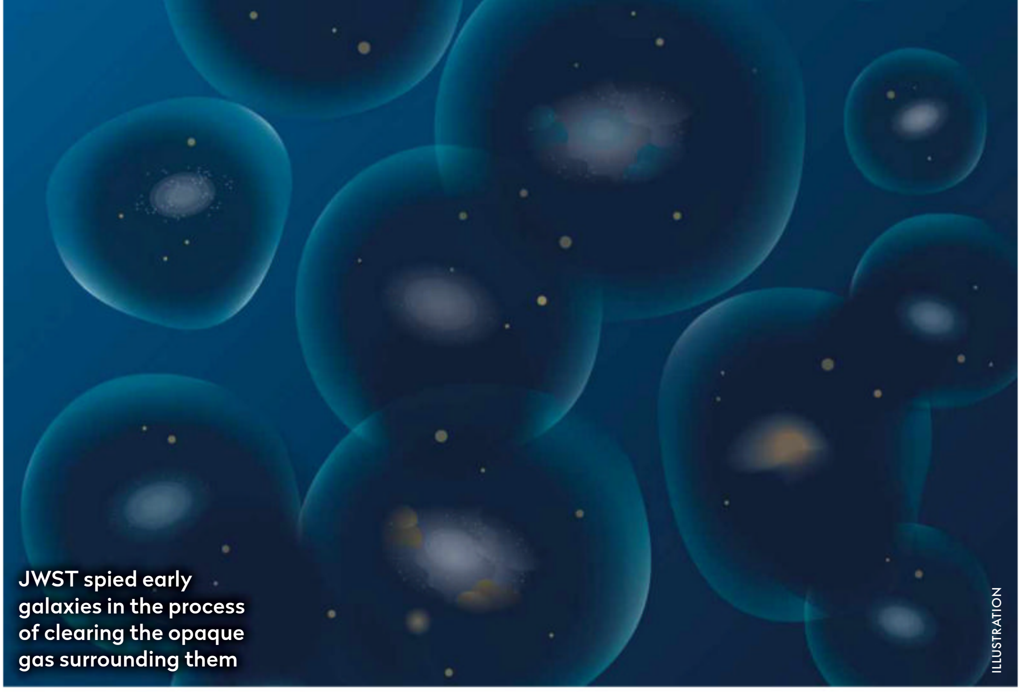
Kepler's last observation run was able to get one week of high-quality observations of 33,000 stars, followed by 10 days of noisier measurements when the lack of fuel made the spacecraft's thrusters fire erratically. There was still enough data to identify potential planets and so the team passed the data through the same detection method they'd used to identify many other planets: a dedicated team of citizen scientists who combed through the light curves looking for transits.

"They can distinguish transits from other wacky things like a glitch in the instrument," says Andrew Vandenburg from MIT, who co-led the study. "That's helpful, especially when your data quality begins to suffer like it did in K2's last bit of data."

The citizen scientists examined the high-quality data, helping to identify three potential planets. For two of these – K2-416 b, which is 2.6 times the mass of Earth and takes 13 days to orbit its star, and K2-217 b, a three-Earth-mass planet with a 6.5-day orbit – the team were able to identify another transit signal in the brief periods of reliable data in the final 10 days, thereby confirming them as planets. They could find no additional transit for the third candidate, EPIC 246251988 b, a Neptune-sized object orbiting once every 10 days, and so this will require further follow-up observations.

"We have found what are probably the last planets ever discovered by Kepler, in data taken while the spacecraft was literally running on fumes," says Vandenburg. "The planets themselves are not particularly unusual, but their atypical discovery and historical importance makes them interesting."
www.nasa.gov/kepler

NASA/JPL-CALTECH, NASA, ESA/CSA/JOYCE KANG (STSCI), NASA/ESA/ELIZABETH WHEATLEY (STSCI), NASA/JPL-CALTECH/ASU/MSSS



JWST spied early galaxies in the process of clearing the opaque gas surrounding them

ILLUSTRATION

Landmark find as clearing cosmic fog witnessed

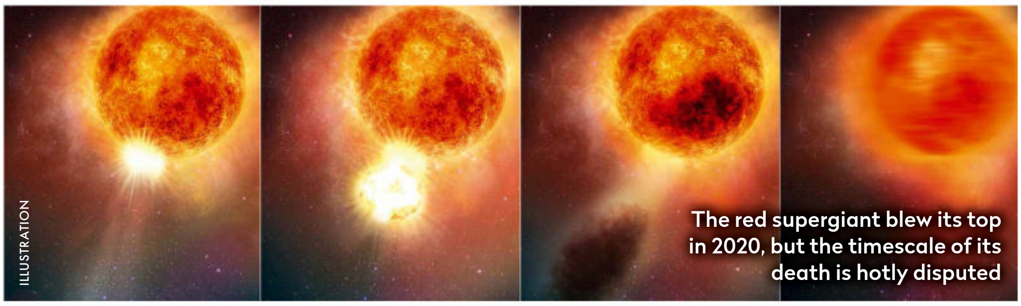
The observation proves that galaxies transformed the early Universe

Astronomers have witnessed galaxies clearing the early Universe's obscuring fog of opaque gas for the first time, thanks to the James Webb Space Telescope.

A few hundred million years after the Big Bang, space was filled with cool gas that absorbed most of the light travelling through the cosmos. There then followed what is called the Era or Epoch of Reionisation, where starlight from the first galaxies heated the gas, turning the Universe transparent by the time it had reached an age of one billion years old.

To see this in action, researchers examined bright quasars from this era, the light of which shines through the honeycomb of opaque gas and clear bubbles, illuminating transparent regions two million lightyears in radius.

"We expected to identify a few dozen galaxies that existed during the Era of Reionisation – but were easily able to pick out 117," says Daichi Kashino of Nagoya University in Japan, who led part of the study. "Webb has exceeded our expectations." **webbtelescope.org**



ILLUSTRATION

The red supergiant blew its top in 2020, but the timescale of its death is hotly disputed

Astronomers differ over Betelgeuse's demise

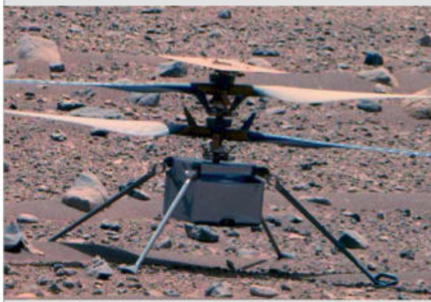
Could Betelgeuse go supernova within the next few decades? Two papers are arguing whether that might be the case. Betelgeuse, a red supergiant 500–600 lightyears from Earth will one day go supernova, but exactly when that might be is a subject of much debate.

One study led by Hideyuki Saio from Tohoku University in Japan simulated the star's vibrations, leading them to believe the star could be in the final stages of its life, where it is burning carbon in its core. This stage will only last around 1,000 years and once the fuel is exhausted, the star would go supernova within a decade.

However, another group led by László Molnár from Konkoly Observatory in Hungary has since replied with their own measurements of Betelgeuse's vibrations that suggest the star is still in its earlier helium-burning stage, which could last for up to 100,000 years.

Regardless of its ultimate fate, Betelgeuse has been garnering much attention of late, after a huge ejection of dust caused the star to dim from its usual magnitude of +0.5 to just +1.6 in early 2020. The aftershocks of this event are likely to affect the star for several more years, as seen this May when the star brightened by almost 50 per cent, to +0.0. **www.aavso.org**

NEWS IN BRIEF



Ingenuity falls silent

NASA's Ingenuity helicopter, which is accompanying the Perseverance rover on Mars, lost contact with Earth for six Martian days in April. A ridge blocked the signal between the two, but they reconnected once the rover moved closer to Ingenuity's last-known landing site.

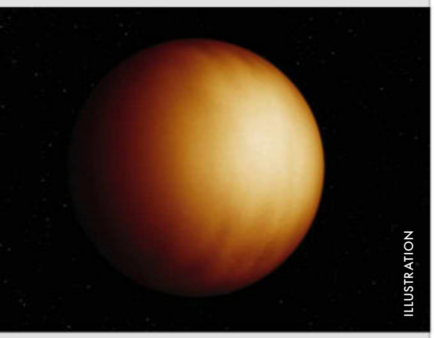
No Jupiters for red dwarfs

A study of over 200 red dwarf stars, the most common in the Universe, failed to find a single Jupiter-sized world, leading astronomers to conclude that large planets may be rare around them. As Jupiter was key in shaping our Solar System, their absence could have big implications for finding habitable worlds around red dwarfs.

Volcanic planet could be habitable

Despite being an unlikely candidate, tidally locked exoplanet LP 791-18 d could be a habitable world. Though one side of the planet constantly faces its star, intense volcanic activity on the world could generate an atmosphere capable of allowing liquid water to condense on the planet's dark side.

NEWS IN BRIEF



Mapping exoplanet atmospheres

Astronomers have mapped the temperature of tidally locked exoplanet WASP-18 b with the JWST by watching it as it passed behind its star. The map shows the hottest point facing the star is around 1,000°C warmer than the terminator, where day and night sides meet.

NLC monitoring goes on

A new satellite from the USA's National Oceanic and Atmospheric Administration, NOAA-21, has taken up the mantle of monitoring noctilucent clouds after the AIM satellite stopped functioning earlier this year. NOAA will release daily maps to aid astronomers hoping to catch the shimmering clouds for themselves.

Faintest galaxy is real

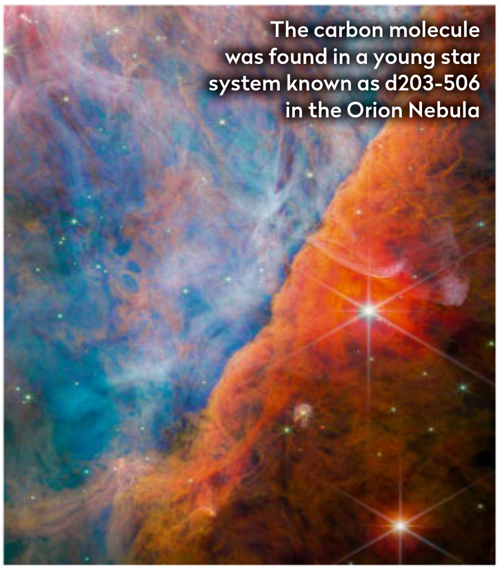
Astronomers have confirmed the faintest galaxy ever seen in the early Universe by the JWST does actually exist. JD1 is so far away we're seeing it as it was 13.3 billion years ago, when the Universe was just 4 per cent its current age. Most galaxies from this era are unusually bright, but JD1 appears to be far more like a typical galaxy for the era.

NASA/ESA/G. BACON, ESA/WEBB/NASA/CSA/M. ZAMANI (ESA/WEBB) PDRS4ALL ERS TEAM, NASA/JPL-CALTECH (K. MILLER/IPAC)

BULLETIN

Crucial ingredient of life found by JWST

Molecule discovered around an infant star in the Orion Nebula


The carbon molecule was found in a young star system known as d203-506 in the Orion Nebula

A key carbon compound which helps to form the building blocks of life has been found around a distant star by the JWST for the first time. The molecule, methyl cation (CH_3+), was uncovered in the planet-forming protoplanetary disc around a red dwarf star in the Orion Nebula. The molecule helps promote chemical reactions, allowing the formation of the complex carbon molecules all known life is based on.

Intriguingly, the red dwarf is surrounded by several large stars that are bombarding the disc with ultraviolet radiation. Normally, this radiation breaks carbon molecules apart, hindering their creation, but in this case it appears to be providing the energy needed for methyl cation (pronounced cat-eye-on) to form.

"This clearly shows that ultraviolet radiation can completely change the chemistry of a protoplanetary disc. It might actually play a critical role in the early chemical stages of the origins of life," says Olivier Berné from the French National Centre for Scientific Research in Toulouse, who led the study.
webbtelescope.org

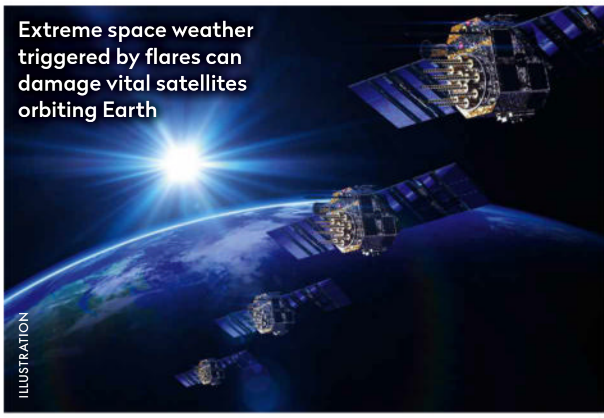
Solar activity silences radio communications

A solar flare strong enough to knock out shortwave radio communications over North America for 45 minutes struck Earth on 20 June. The flare was one of an increasing number of X-class flares – the strongest type of solar flare – seen erupting in recent months, as the Sun enters the most active portion of its 11-year solar cycle.

Shortwave radio communications, such as those used by aviators and international radio broadcasts, bounce signals off the upper level of Earth's atmosphere, called the ionosphere. However, the electromagnetic radiation released when a large solar flare erupts can ionise this atmospheric layer, stopping the signals from bouncing properly.

The flare was accompanied by a coronal mass ejection (CME) travelling at 3.5 million km/h, though this predominantly missed Earth. Had it hit, such CMEs can compress Earth's magnetic field, causing electric currents to surge along power cables, triggering power blackouts.

The flare comes shortly after the British Antarctic Survey released a new set of



Extreme space weather triggered by flares can damage vital satellites orbiting Earth

benchmarks for solar activity. These set out the size of the most dangerous solar event you would expect to see once every 10, 50 or 100 years. Their aim is to help spacecraft manufacturers, planners and insurers in assessing and compensating for potential risks to satellites from the Sun.

Turn to **page 66** to learn more about the Sun's current activity.
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CUTTING EDGE

Humble dust could hamper ambitions to build settlements on the Moon

ILLUSTRATION

Lunar landings could create a dust dilemma

Moondust kicked up by spacecraft may cause problems for those in orbit

There are plans for a lot of crewed missions to the Moon in the coming years. Artemis, led by NASA but with involvement of ESA, JAXA and the Canadian Space Agency as well as commercial spaceflight partners, aims to return the first humans to the Moon since the Apollo programme. If all goes well, this will be followed by the establishment of permanent human settlements on the lunar surface. All of this would involve landing not just the crews themselves, but all the habitats and infrastructure needed to support them on the surface, and so requiring a lot more – and crucially, much heavier – landers than used by Apollo.

One important consideration for such massive landers, say Philip Metzger at the Florida Space Institute and James Mantovani at NASA Kennedy Space Center, is how much surface material their rockets will kick up into space. Because the Moon is airless and has much lower gravity than Earth, these sprays of ejecta particles can be blasted at high speeds right up to orbital altitudes.

Metzger and Mantovani modelled a lander of 40 tonnes (over 2.5 times heavier than the Apollo lunar modules) touching down onto the Moon and calculated the quantity, size and trajectory of lunar material that would be blasted up into space.

A key part of the planned human exploration of the Moon will be the Lunar Gateway, a space station in lunar orbit that will serve as a staging point for missions down to the surface. Metzger and Mantovani calculated that every square metre of the Gateway would experience around 10,000 impacts of dust-grain-sized particles as it orbited. But even considering as many as 100 landings onto the Moon, and assuming that Gateway passes through each lingering ejecta sheet 10 times, less than 0.1 per cent of Gateway's structure will be abraded to a few microns deep. The authors note that this damage should nonetheless be taken into account when designing the Gateway and its operation.

However, the Lunar Gateway will orbit between 1,500km and 70,000km from the surface. For a spacecraft in low lunar orbit the situation is much worse. Metzger and Mantovani considered a spacecraft orbiting at an altitude of 110km above the lunar surface, matching the parking orbit of the Apollo command modules. At this lower altitude, the spacecraft has a much higher orbital velocity of around 5,800km/h and as the ejecta hasn't climbed as far against the Moon's gravity, it will be travelling at a much faster 16,000km/h. On top of that, the plume won't have dispersed as much, so the density of impacts will be greater too. Such a low orbiting spacecraft could sustain extensive damage, the researchers calculating that around 4 per cent of any exposed glass would be pitted and eroded. This could impair visibility through windows and reduce the power-generating ability of solar panels.

"Because the Moon is airless and has much lower gravity, sprays of ejecta particles can be blasted right up to orbital altitudes"

The news isn't all bad, though. As well as outlining the hazards, the researchers describe possible solutions. The first surface missions could construct robust landing pads that would greatly reduce the amount of material ejected up into orbit, or landings could be carefully choreographed to ensure orbiting spacecraft miss the worst of the ejecta sheets.

Prof Lewis Dartnell is an astrobiologist at the University of Westminster

Lewis Dartnell was reading... *The Damage to Lunar Orbiting Spacecraft Caused by the Ejecta of Lunar Landers* by Philip T Metzger and James Mantovani **Read it online at: arxiv.org/abs/2305.12234**

NASA, TOMMY NAWRATIL/CCDGUIDE.COM, CHRISTOPH KALTSEIS/CCDGUIDE.COM

Massive stars ditch their discs

Stars in Sigma Orionis seem to shed materials that could build new worlds

Prof Chris Lintott is an astrophysicist and co-presenter on *The Sky at Night*

I've spent longer looking at the Orion Nebula than any other object, peering through eyepieces hoping for one of those moments of clarity that will cause the three-dimensional structure of the gas that wraps around the young stars of this nearby nursery to snap into focus. A battered poster of the Hubble image of this most intriguing of objects was stuck to my wall for years too.

That Hubble image contained within it exciting shadows, the silhouettes of discs of material surrounding many of the nebula's young stars. At the time, they were taken to be the rough material from which planetary systems were forming, and much work has been done since to try to confirm that we are, in fact, seeing the creation of solar systems in Orion.

The authors of this month's paper, from India and from Edinburgh, are similarly on the trail of newly forming planets, looking not at the main nebula but at neighbouring Sigma Orionis. Located just below the eastern end of the belt of Orion, southwest of the star Alnitak – and often featuring in images of the Horsehead Nebula – it appears to be a single star to the naked eye. The first telescopic observers realised it was a binary system, but it's far richer – we now know that it's actually a young cluster of stars. The cluster happens to lie in a part of the sky where there is relatively little dust lying between us and it, and so it's a prime target for those seeking to understand the behaviour of young stars.

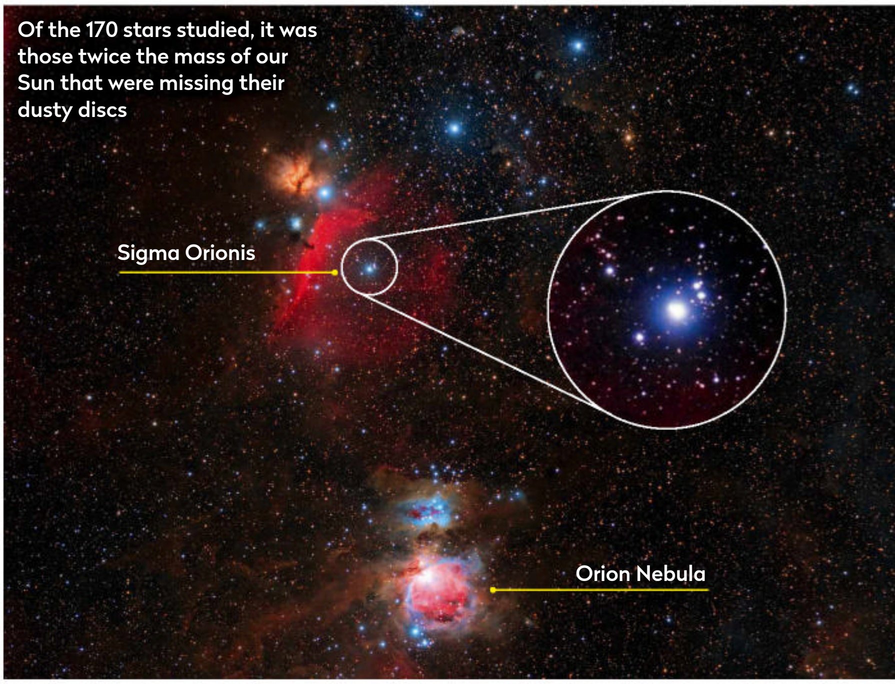
As in so many studies of the Milky Way and its denizens these days, the authors start with data from the Gaia mission, ESA's celestial cartographer which has spent most of the last decade measuring the positions and motions of over one billion stars in our Galaxy. This data allowed the team to confidently identify 170 stars which are part of the Sigma Orionis association; not bad for something which previous generations of astronomers were convinced was 'just' a binary system.

The team combined data from the large Canada–France–Hawaii telescope on Mauna Kea in Hawai'i with infrared surveys from NASA's plucky WISE telescope to work out which of these stars have discs, the dust from which will form planets and which will shine brightly in the infrared. In all, 40 per cent of the young stars have discs, a number that seemed small to me at first – after all, now we know most stars have planets we should perhaps expect most of them to have discs too.

> ***"These massive stars shrug off any discs they have quickly. Planets forming in such environments will need to get a move on"***

The authors point out that it is the more massive stars, those weighing in at twice the mass of the Sun, that are missing discs. These stars, which brighten quickly, presumably shrug off any discs they have quickly, their light and activity being too much for the weakly bound material. Planets forming in such environments will need to get a move on.

At the other end of the mass spectrum, the team look at brown dwarfs, some of which are small enough that they might as well be planets themselves. The smallest brown dwarf was shown to have a disc weighing just 20 times the mass of Jupiter – about 2 per cent that of the Sun. With such tiny stars common across the Milky Way, the most common type of planet may be one with a faint red star in its sky.



Of the 170 stars studied, it was those twice the mass of our Sun that were missing their dusty discs

Chris Lintott was reading… *Protoplanetary Disks around Young Stellar and Substellar Objects in the σ Orionis Cluster* by Belinda Damian et al. **Read it online at: arxiv.org/abs/2305.18147**

The Sky at Night TV show, past, present and future

INSIDE THE SKY AT NIGHT

▲ While the idea of alien life gets imaginations running riot, we can be certain of some things, says Arik Kershenbaum, and universal principles govern what is and isn't possible for complex, intelligent life on other worlds

SCIENCE PHOTO LIBRARY/ALAMY STOCK PHOTO, SARAYUT/ISTOCK/GETTY IMAGES, ESA/HUBBLE/DIGITIZED SKY SURVEY/NICK RISINGER/N. BARTMANN

In the latest episode of *The Sky at Night*, **Arik Kershenbaum** considers whether it's inevitable that intelligent alien civilisations are out there

Everything we know about life – what it is, what it looks like and how it works – has come from studying life on our planet. This creates a problem for those of us who look for signals from extraterrestrials. How can we plan to communicate with an extraterrestrial intelligence, when we've not even found evidence for the existence of any form of alien life at all?

You might think that alien life will be very different from life on Earth – very *alien*. But that may be a little pessimistic. While it's good to be cautious and to remember that our experiences on Earth may not prepare us fully for all the weird and wonderful possibilities that exist across the Galaxy, it's also true that not *everything* is possible. Just as the universal laws of physics constrain the nature of planets and stars, so the laws of biology constrain what kind of life is possible, and in particular, what intelligent life must be like.

First among these 'universal laws of biology' is that all life in the Universe must have evolved through natural selection. Evolution isn't a peculiar mechanism that exists only on our planet – it's an inevitable process that is the only way for life-like complexity to accumulate. It's a constraint just as rigid as the laws of stellar nucleosynthesis that govern which elements can and can't be produced inside stars. And because we know quite a lot about the theory behind natural selection, we can say a lot about what must constrain life on other planets too.

For example, at the simplest level, life must reproduce. It is only by having offspring – and offspring that are different from each other – that life can become more and more complex, generation after generation. Those traits that are more successful – maybe longer teeth or brighter feathers, or whatever the alien equivalent might be – will become disproportionately represented in successive generations. Complex variety in lifeforms can *only* arise step by step, generation by generation.

Making life difficult

Another rule that is often forgotten is that complex life doesn't arise for its own sake – complexity evolves because organisms need to solve complex problems. Finding food, or avoiding becoming someone else's food, for example. Complex life only comes into existence if there is a complex set of interactions between lifeforms on a planet. If we were to discover complex life elsewhere, we could be sure that there

Arik Kershenbaum is a zoologist at the University of Cambridge. His book *The Zoologist's Guide to the Galaxy* is out now

must be a complex ecosystem, with different organisms all vying against each other for advantage.

What about intelligence? What are the chances that there are intelligent aliens out there waiting to contact us? We know that 'intelligence' in its simplest form evolved on Earth very quickly: as soon as animals evolved that had to look out for enemies, find food and attract mates. All animals on Earth have some form of intelligence, because that's the very nature of what it is to be an 'animal', and animals have been around for probably over 600 million years. But it took those same 600 million years for animals to evolve an intelligence that allows us to send messages to the stars and to listen for messages in return. Why so long? Is the kind of intelligence that allows an organism to build spaceships and radio telescopes very rare in the Universe? Perhaps we will find the Galaxy teeming with life, but no life with which we can have a conversation.

I think not. If there are many other worlds with complex ecosystems of different kinds of organisms – the alien equivalents of plants and animals and fungi, and probably other strange kinds of creatures too – then that inexorable process of the evolution of technological intelligence is already under way on other worlds. Or possibly even well ahead of us.

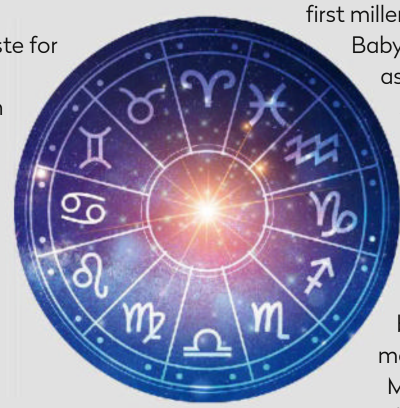
Looking back: The Sky at Night

27 August 1979

Patrick Moore made no secret of his distaste for the "superstition" of astrology, but even he couldn't deny its inextricable link with astronomy. In the 27 August 1979 episode of *The Sky at Night*, he took the time to look at the ties between them.

The zodiac is the apparent path of the Sun across the celestial sphere over a year. As this is closely related to the plane of the Solar System, it's also the line the planets roughly follow. Because of this, the constellations crossing this region have been given great meaning by many cultures across the globe.

According to Ptolemy's star catalogue, on which most western constellations are based, there are 13 star patterns that cross the band. In the first millennium BC, the Babylonians set 12 of these as the astrological star signs we recognise today (for ease they left out Ophiuchus, which just clips the zodiac between Scorpius and Sagittarius) and began using the motions of the planets, Moon and Sun through these to make predictions of the future.



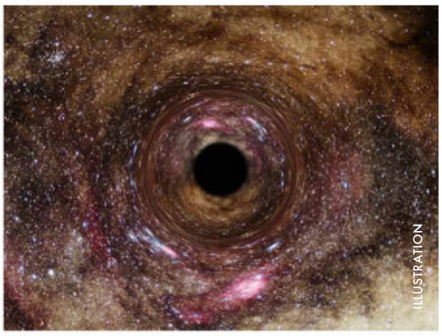
▲ Astrology and astronomy were closely linked for centuries

The practice spread, and for centuries the task of plotting the stars and planets was taken up by spiritual leaders, with little distinction between mysticism and scientific study. This began to shift in the 17th century, as the invention of the telescope led to better understanding of the heavens, resulting in two very disparate disciplines: the mystic art of astrology and the scientific study of astronomy.

Black Holes: Searching for the Unknown

This month *The Sky at Night* team investigate the latest discoveries in the science of black holes. Maggie and Chris meet the scientists using incredible techniques to uncover their secrets, from brand new supernovae to the recent discovery of an ultramassive black hole.

BBC Four, **14 August,** 10pm (first repeat will be on BBC Four, **17 August**, 7pm)
Check www.bbc.co.uk/skyatnight for more up-to-date information



▲ **This year, astronomers discovered an ultramassive black hole over 30 billion times the mass of our Sun**

Emails – Letters – Tweets – Facebook – Instagram – Kit questions

INTERACTIVE

Email us at **inbox@skyatnightmagazine.com**

MESSAGE OF THE MONTH

This month's top prize: two Philip's titles

The 'Message of the Month' writer will receive a bundle of two top titles courtesy of astronomy publisher Philip's: Nigel Henbest's *Stargazing 2023* and Robin Scagell's *Guide to the Northern Constellations*

Winner's details will be passed on to Octopus Publishing to fulfil the prize

A gift that keeps giving

For my 40th birthday last year, my family kindly bought me a telescope. I'd had limited success using it in the confined space of my back yard, but at the end of May I was able to attempt my first photos of the (waxing) Moon. Here's one that I was able to get using a friend's astro-modified Canon camera. I was away in Italy over the final weekend of the month and was disappointed not to be able to photograph this Strawberry Moon, but I was able to at least see it hanging large and low over the Ligurian Sea! I'm hoping I'll get another crack at it when the next full Moon rolls around... if I can see it from my yard.

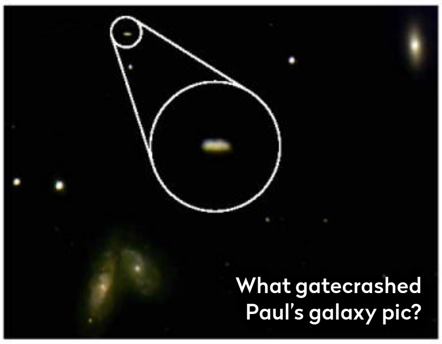
Peter Martin, via email

What a clean, crisp image, Peter, and very well composed too – we look forward to seeing more of your photos in our Gallery pages! ***– Ed.***

▲ **Yard luck: Martin got this fabulous Moon shot from his back yard on his first attempt**

Tweet

AstroNebulee
@AstroNebulee • 11 June
The Milky Way core taken over the village slate quarry here in Delabole, Cornwall 12-5-23 (only just got around to this) 10x 13sec for MW, 4x 1min foreground.
#Astrophotography #milkyway #PhotoHour @skyatnightmag



What gatecrashed Paul's galaxy pic?

Picture puzzle

Having read with pleasure some of the 'mystery object' letters in your magazine, I thought I would send my mystery to you to see whether you might un-riddle it. At 22:22 EDT on 18 June 2023 (03:22 UT on 19 June 2023), I was live-stacking NGC 4567–4568 for the sake of the supernova that was recently seen there, and when I'd processed the stacked image (see above) I was puzzled to see the streak of a moving object (circled). The stack comprises 100x 8-second exposures. The size of the streak suggests it's too slow to be a meteor or Starlink satellite (or a firefly!) and too fast to be an asteroid belt object. Perhaps it's some sort of artefact that I somehow generated. I could track it clearly in the individual stack frames, moving from right to left, while the other objects in the frame do not move on a relative basis. I cannot figure what artefact it might be, if it is one. Suggestions welcomed.

Paul Lahti, via email

In that position, at the date and time you took the image, Paul, the most likely candidate for your mystery object is asteroid 1627 Ivar (mag. +14.8), which is 123 million kilometres distant, on the asteroid belt's inner edge. ***– Ed.***

Bob's stacked image of 8x 30s exposures, cropped, stretched and annotated in Photoshop Elements

Mystery chain

I read with interest your Message of the Month in the June edition from Greg Sanders, who inadvertently captured a 'mystery object' in his image of Markarian's Chain on 21 April 2023. You concluded that it could well be minor planet 521 Brixia. By pure chance, I managed to image Markarian's Chain on the same night. My image was taken at 20:41 UT and shows 521 Brixia just above NGC 4425. On further inspection, I also found asteroid 194 Prokne in the bottom right-hand corner of the image. This was my first attempt at imaging this galaxy cluster and was a bit of a trial. The image is a stack of eight 30-second images taken with my Canon EOS 250D camera and 70–300mm lens at 300mm, mounted on a Sky-Watcher Star Adventurer tracking mount and set at f/5.6 and ISO 1600.

Bob Okines, Sussex Sidewalk Astronomers

Tribute act

My son Elliott is currently doing his GCSE astronomy exams at Woking High School and he has taken this photo of himself as Ole Rømer for his teachers to remember him! In the future ▶

ON FACEBOOK

WE ASKED: What was there before the Big Bang?

Alina Craig I recently thought of how a tiny seed explodes into life and creates this complex and magnificent structure which is a plant. The new plant has no knowledge of what was there before the seed germinated.

James Dow What's north of the North Pole?

John Drake Our capability to answer this is as likely as my dog understanding how the TV works! Maybe by the time we have evolved into the Eloi we might (comparatively) learn how to switch the TV on.

Paul Adamson I went on an astronomy course at Greenwich Observatory many years ago. I asked the tutor what happened before the Big Bang and he suggested we go to the local pub and ask someone there, as they would have as much of an idea as anyone.

Tim Caldwell Our minds simply aren't equipped to answer this equation. Was it God? Who created God? Are we in a simulation? Who created the simulation? It's an infinite loop of questions and answers. None of us are clever enough to answer.

SCOPE DOCTOR

Our equipment specialist cures your optical ailments and technical maladies

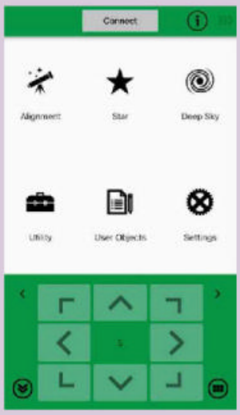
With **Steve Richards**

Email your queries to
scopedoctor@skyatnightmagazine.com

I have a Sky-Watcher Star Discovery 90i WiFi computerised telescope, but I'm struggling to use the Go-To system. Can you help?

DAWN RUTHIN

This telescope is made up of a 90mm refractor and an altazimuth Go-To mount controlled by the SynScan smartphone app. Instead of a hand controller, it comes with a Wi-Fi adaptor and this must be plugged into the mount socket marked 'HC'. The mount manual doesn't include information on the Wi-Fi adaptor or the SynScan app, so we recommend downloading manuals for both these as they'll give instructions for operating the Go-To system. You can find both documents at **skywatcher.com/download/manual**.



▲ Use the SynScan app to connect your mobile to the scope's Wi-Fi network

Start by downloading the free SynScan app (App Store for iOS or Google Play for Android). Set the mount to the Home position (level the tripod top and telescope tube and point the tube true north). Turn on the mount and use the system setting of your smartphone to join the network produced by the Wi-Fi adaptor. Open the SynScan app, tap 'Connect' on the top toolbar, then carry out a one- or three-star alignment. Finally, choose an object that you would like to observe from one of the catalogues.

Steve's top tip

What is an Airy disc?

An Airy disc is a bright, circular spot of light formed in the centre of an image. It happens as light passes through a circular aperture, such as found on a telescope, and is a result of the light waves being diffracted. By aiming a telescope at a bright star, which is essentially a point source of light, centring it in the field of view and then defocusing the star image, close inspection will reveal a series of bright and dark concentric rings. By examining the shape of these rings, astronomers are able to identify optical and collimation issues in their telescopes.

Steve Richards is a keen astro imager and an astronomy equipment expert

BBC Sky at Night MAGAZINE

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Editor Chris Bramley
Content Editor Iain Todd
Features Editor Ezzy Pearson
Art Editor Steve Marsh
Production Editor Jane Williamson
Reviews Editor Paul Money

CONTRIBUTORS
Paul Abel, Stuart Atkinson, Mark Bowyer, Anita Chandran, Jane Clark, Lewis Dartnell, Glenn Dawes, Chris Grimmer, Tim Jardine, Arik Kershenbaum, Pete Lawrence, Martin Lewis, Chris Lintott, Mary McIntyre, Elias Miller, Laura Nuttall, Jonathan Powell, Emma Johanna Puranen, Katrin Raynor, Steve Richards, Giles Sparrow, Steve Tonkin, Paul Wootton

ADVERTISING SALES
Advertising Executive Andy Williams
+44 (0)117 300 8803, Andy.Williams@ourmedia.co.uk
Inserts Laurence Robertson +353 (0)87 690 2208

PRODUCTION
Production Director Sarah Powell
Production Coordinator Hannah Gazzard
Ad Services Manager Paul Thornton
Ad Coordinator Charles Thurlow
Ad Designer Parvin Sepehr
Reprographics Tony Hunt, Chris Sutch

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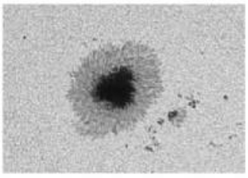
▶ he hopes to study astrophysics at university, then research exoplanets. Thank you to the astronomy teachers!
Julie Newsam, via email

Season of the stitch

I first saw the Orion Nebula on the news in 2019 and it planted the seed for a quilt in my mind. I spent the next few years designing and making the quilt (in between making others) from memory, not looking for any further pictures. When it was completed this week, I then researched pictures of the Orion Nebula and was delighted to see how similar my quilt was – it's been a very enjoyable creative journey. I'm going to exhibit the quilt at the Lullingstone Quilt and Craft Festival from 14–16 July.
Gill Nicholls, via email

Here comes the Sun



Despite the lack of planets close by and any deep-sky imaging being way past my bedtime, I've been pleased to find the Sun becoming active again. With my homemade Baader solar filter, I managed to image one giant sunspot a few weeks ago using my 8-inch Sky-Watcher telescope, a ZWO ASI120MC camera and a 2x Barlow lens. The advice is to cool down and acclimatise our outfits to avoid thermal currents, but despite standing my scope in full Sun and restricting the tube with a filter, I managed this shot. It was processed from a 90-second video with AutoStakkert! and RegiStax and I was pleased with the amount of detail produced – and the fact that I can observe during the day!
John Consadine, Dereham, Norfolk

Instagram

juliencaptures • 20 June

With the help of @flightradar24, I was able to determine whether from my location an airplane would be flying in front of the Sun over the next few minutes. It was not necessarily a difficult image to take, but it needed a lot of perseverance and persistence. @bbcskyatnightmag

SOCIETY IN FOCUS

Orpington Astronomical Society attracts first-class speakers to its monthly meetings in Petts Wood, southeast London. Members unable to get there can join us online, though they'll miss out on the tea and biscuits! Our monthly Otford Observing Evenings are opportunities for fledgling astronomers to see telescopes in action and discover the rudiments of observing. We run an extensive programme of visits to places of interest, including the Royal Observatory Greenwich, with whom we have close links. Next year we're visiting the La Palma observatories on the Canary Islands.

Outreach forms an important part of our charitable activities, with regular visits to local schools, clubs and associations to talk about astronomy and show off our solar telescopes. OAS members are a sociable bunch, with an annual Starbeque (this year complete with a water rocket competition and the launch of some real rockets) and occasional picnics. We also stay in touch through TOAST, our quarterly newsletter, and our website's forum, and our very active imaging group publishes amazing images each month.

▲ **OAS members during an outreach event this summer at Lullingstone Park, Kent**

Andrew Ramsay, Chair, OAS
▶ **orpington-astronomy.org.uk**

We pick the best live and virtual astronomy events and resources this month

WHAT'S ON

PICK OF THE MONTH

▲ Astrophysicist Erika Nesvold looks at the ethics of building settlements in space

The Ethics of Space Exploration

Livestreamed from the Royal Institution, London, 10 August, 7pm

Erika Nesvold has a PhD in physics from the University of Maryland and has carried out computational astrophysics research for NASA, SETI and the Carnegie Institute. But she also has a background in ethics, sociology, history and law, and is the author of the new book *Off-Earth: Ethical Questions and Quandaries for Living in Outer Space*. That makes her the perfect host for this livestreamed lecture in which she'll discuss the moral dilemmas and pitfalls involved in the idea of visiting, or perhaps even colonising, other planets – from ecological issues to medical and labour rights. It's a pay-what-you-can event, but there's a minimum donation of £5.
www.rigb.org

Observing the Sun Safely

Norman Lockyer Observatory, Sidmouth, Devon, 16 August, 2:30pm
At this public event, the Observatory's experts will show you how to start observing and photographing the majesty of our star in complete safety. Adults £10, kids £5, members free.
www.normanlockyer.com

Bakineering in Space

Armagh Observatory, Co Armagh, 3 August, 11:30am and 3pm
What does molten sugar have to do with protecting spacecraft from micro-meteors? In this hour-long interactive show, engineer and *Great British Bake Off* finalist Andrew Smyth explores the science that connects cakemaking and space exploration. Adults £16, kids £12.
www.armagh.space

The Perseids and Saturn

Durlston Observatory, Swanage, Dorset, 12 August, 9pm
Join Wessex Astronomical Society for an evening at their observatory. The Perseid meteor shower is the big event, but visitors can also expect views of Saturn and the summer constellations. Entry is £3, but the event is weather-dependent, so check the website on the day.
wessex-astro.org.uk

The Big Wild Sleep Out

RSPB Fairburn Ings, West Yorkshire, 12–13 August, 9:30pm
Wakefield and District Astronomical Society will be taking their telescopes down to the Fairburn Ings nature reserve for this overnight family camping event perfect for young astronomers. See an array of bird life and take part in a solar observing session by day, then watch the Perseid meteor shower by night. £35.50 per adult, £30.50 per child.
wakefieldastronomysociety.co.uk

Astro Engineering

IQ Building Room 001, University of Swansea, 24 August, 7:15pm
Well-known astronomy writer and speaker Bud Budzynski presents a talk on astro engineering. Held in person and over Zoom, the event is hosted by Swansea Astronomical Society, but potential new members are welcome – as are members of other astronomy societies.
www.swanastro.org.uk

The Barwell Meteorite

Aston University, Birmingham, 29 August, 7:30pm
Birmingham Astronomical Society hosts Martin Lunn, FRAS for the story of the 4.5bn-year-old, 44kg chondrite that crashed to Earth in the Leicestershire village of Barwell on Christmas Eve 1965.
www.birmingham-astronomy.co.uk

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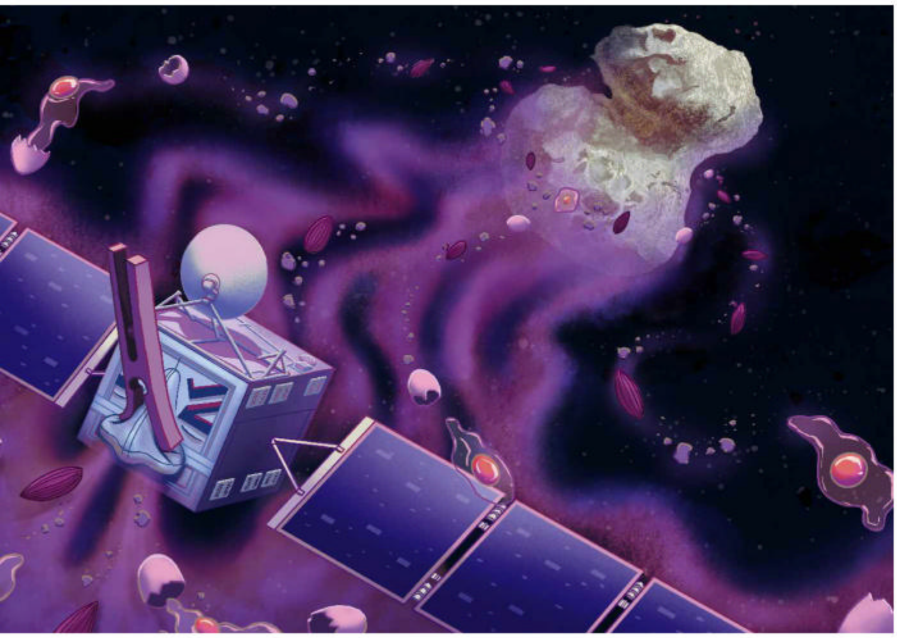
BBC Sky at Night MAGAZINE

FIELD OF VIEW

What does space smell like?

From rum to rotten eggs, **Jonathan Powell** turns his nose to heaven's scents



Jonathan Powell is a freelance writer and broadcaster. A former correspondent at BBC Radio Wales, he is currently astronomy columnist at the *South Wales Argus*

From the James Webb Space Telescope's amazing Pillars of Creation photo to the Event Horizon's image of a black hole, we've captured many dramatic and colourful representations of space in a visual sense. We've also captured sounds from space, whether that's the eerie electron 'whistler waves' produced by Earth's Van Allen belts or a meteor's sonic boom as it streaks across the night sky. But what about the smell of space?

In fact, space carries a whole array of odours and to experience some of them we need not travel very far. One such on-your-doorstep occurrence came courtesy of the Winchcombe meteorite. Zipping over the UK on the last day of February 2021, it was widely witnessed, captured by everything from doorbell cameras to vehicle dashcams. After its impact in the area of Winchcombe, a village in Gloucestershire, various fragments were recovered, with reports of a "compost-like" smell emanating from some of the remains. This odour suggested the presence of organic compounds and indeed the meteorite was later classified as carbonaceous chondrite, a throwback to the early formation of the Solar System.

As well as rocks landing on Earth from space, astronauts returning from space have also noted distinct aromas. Once back on solid ground, upon removing their helmets many space travellers have reported experiencing the odour of seared steak, hot metal and welding fumes. During the Apollo 11 mission, Buzz Aldrin commented that his suit smelled like "burnt charcoal" when it was coated with lunar dust. And on board Apollo 17, Harrison Schmitt stated that, "All I can say is that everyone's instant impression of the smell [of the Moon] was that of spent gunpowder".

What could explain these odours? High on the list of contenders is the possible chemical reaction with substances carried on their spacesuits, which would generate a similar odour as astronauts re-enter the airlock of their spacecraft from an airless environment, the repressurisation creating a sort of oxidisation process, like combustion.

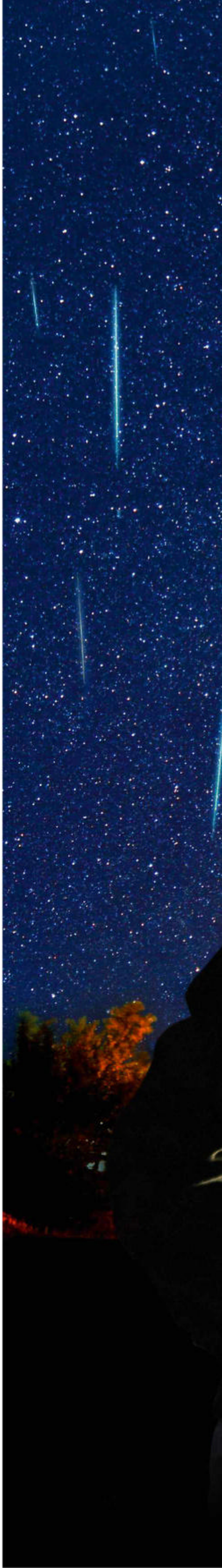
Another explanation could be compounds found in the remnants of long-dead stars, whose essence fills the cosmos. Called polycyclic aromatic hydrocarbons, these are the often-toxic by-products of combustion found in coal, oil and even food.

When it comes to toxic odours, spare a thought for the ESA Rosetta mission. Its 2014 encounter with Comet 67/P Churyumov–Gerasimenko was not only a challenge for those wishing to pronounce it correctly! As the craft followed and monitored the comet, its ROSINA instrument (the Rosetta Orbiter Spectrometer for Ion and Neutral Analysis) inhaled a noxious mix of rotten eggs (hydrogen sulphide), horse urine (ammonia) and almond (hydrogen cyanide), along with formaldehyde.

Even further out into space there's Sagittarius B2, a molecular cloud of gas some 28,000 lightyears distant, which contains huge amounts of ethyl formate, the chemical compound responsible for giving raspberries their flavour and rum its smell – an ideal arena for any space pirates.

The visual aspects of astronomy command so much of our attention, but we shouldn't neglect the aromatic notes of space. For, beyond pictures, they give us a keener sense of what the Universe we live in is composed of.

ELIAS MILLER

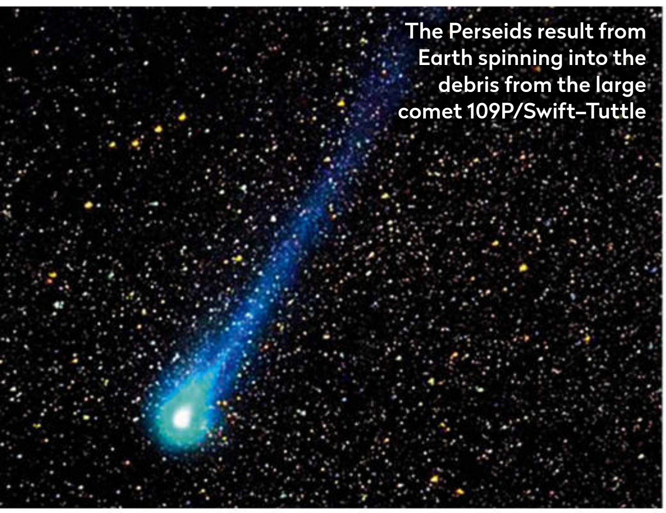


See the **Perseids** *in their prime*

With no bright moonlight to spoil things, 2023 could be a vintage year for summer's strongest meteor shower. **Paul G Abel** tells us how to make the most of the Perseids

PERE SANZ/ALAMY STOCK PHOTO/GETTY, NASA

It may often seem that amateur astronomy is dominated by large telescopes, expensive imaging kit and smartphone apps, but in fact there is still one branch of amateur astronomy that requires practically nothing at all: meteor observing. Although there can be sporadic meteors all year round, we usually observe them when well-established showers are underway. And perhaps the best-known annual meteor shower of them all, the Perseids, takes place this month. With the Moon only a slender waning crescent and very little moonlight to drown meteors out, the prospects for this year's shower are looking good.



The Perseids result from Earth spinning into the debris from the large comet 109P/Swift–Tuttle

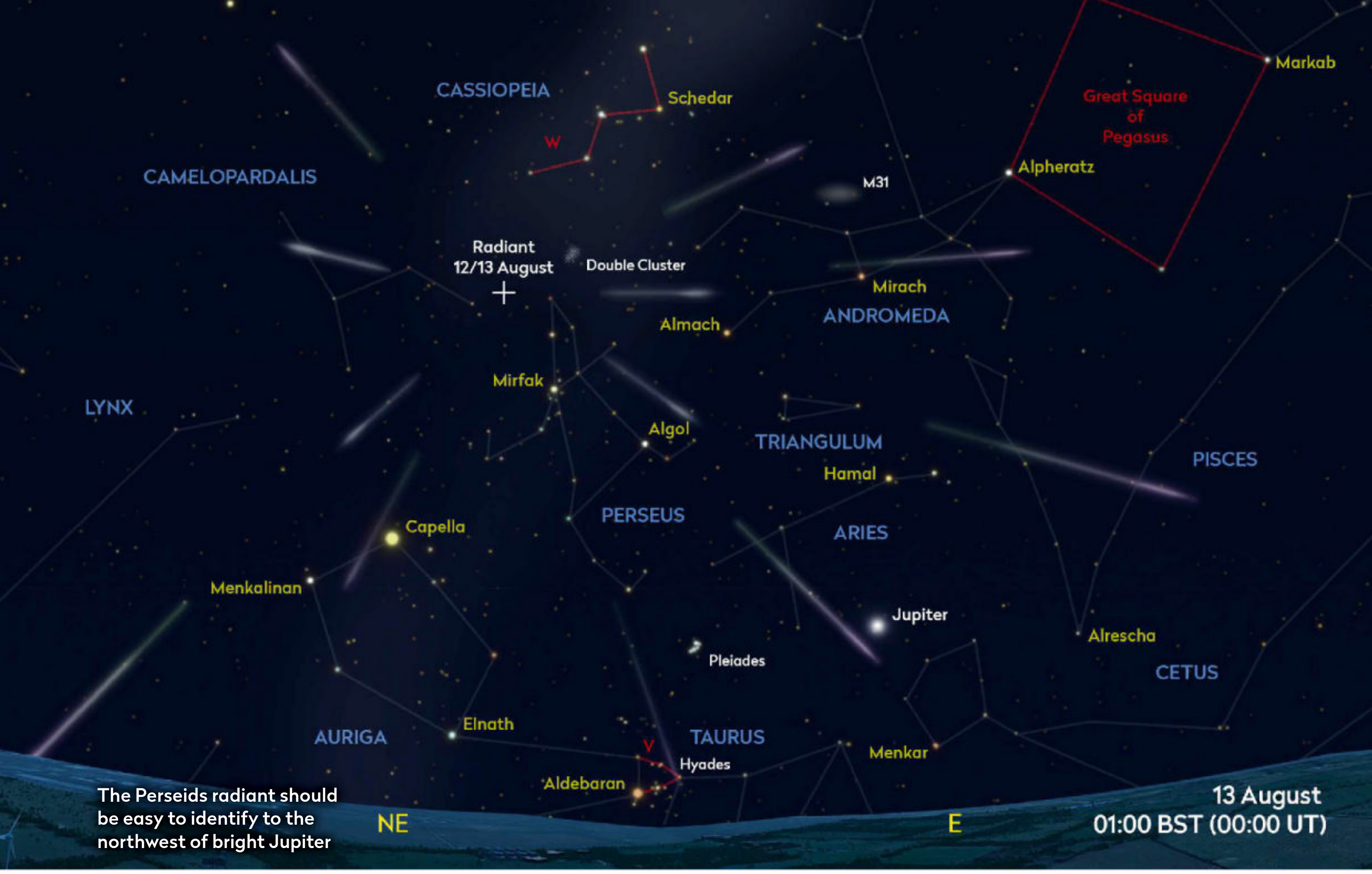
The Perseid meteor shower gets its name from its radiant (the point in the sky where the meteors appear to come from) being in the constellation of Perseus. In much the same way, the radiant of the Geminid meteor shower lies in Gemini, the Leonids have their radiant in Leo, and so on.

As one of the most prolific meteor showers, the Perseids feature in folklore and myth. It used to be said that the Perseid meteors were the 'tears of Saint Lawrence', as some believed they were the sparks from the fire on which Saint Lawrence was martyred in 258 AD. We had to wait until 1866 for the real cause of the shower to be identified: that was when Italian astronomer Giovanni Schiaparelli correctly identified comet 109P/Swift–Tuttle as its source, which passes through the inner Solar System every 133 years.

What are meteors?

It is the dust in a comet's tail that becomes meteors. As a comet approaches the Sun, the increasing heat causes volatile material on the comet's surface to evaporate, taking dust with it to create the tail of particles. A comet's tail can be quite spectacular to observe, and out in space the stream of dust can stretch much further, spanning the distances between planetary orbits. For comets in short orbits, this process happens fairly frequently and, as a result, multiple debris streams from different comets are generated, the streams orbiting the Sun just as the planets do. ▶

With the Moon off the scene, the Perseids peak on 13 August could bring a bonanza of bright, colourful shooting stars



The Perseids radiant should be easy to identify to the northwest of bright Jupiter

▶ When Earth passes through one of these streams, the particles within it hit our atmosphere and burn up in it, becoming meteors. In the case of the Perseids, most of these particles are the size of sand grains, but it is not uncommon for larger pieces to enter the atmosphere, creating fireballs. The effect of a radiant is simply due to perspective; in much the same way as parallel railway tracks appear to meet on the horizon, so parallel meteor trajectories appear to come from one spot in the sky.

Unlike last year, when the Perseids coincided with a full Moon, its strong moonlight drowning out all but the brightest meteors, this year the observing conditions on the night of peak activity (12–13 August) will be very good. The Moon is largely out of the way, a 9%-lit waning crescent setting at 7.32pm on the 12th and rising at 1.40am on the 13th.

The shower really starts on 17 July, when Earth first meets the outer edge of the debris stream from comet 109P/Swift–Tuttle, and runs until 24 August. The peak of meteor activity is when Earth meets the thickest part of the debris stream, with a predicted Zenith Hourly Rate (ZHR) of 80 meteors an hour. It should be noted that the ZHR is an idealised figure – it's the average number of meteors you would see in a very dark sky, with the radiant directly overhead, looking at the entire 180° of sky. On the night in question, less than 80 meteors an hour may be seen – or there might be a great deal of activity where many more are seen. This is why it's worth observing!

Observing the Perseids requires no special equipment, but it is worth planning your session so that you get the most out of it, regardless of whether you plan to make observations or just watch the show. Some basic materials will help with this (see What to bring on a meteor watch, right). Make sure you are warm and comfortable; it can get surprisingly chilly in the early hours of the morning in August.

CHART BY PETE LAWRENCE, RON GARAN/NASA, PETE LAWRENCE X 2

▲ What a Perseid looks like from space. This trail was captured by crew on the International Space Station in August 2011

Best time to see them

It will be best to start observing at about midnight BST on 13 August (23:00 UT on 12 August). The sky should be sufficiently dark by this time and the constellation of Perseus should be visible low in the northeastern sky. The constellation should be easy to identify: look towards the east and the brilliant planet Jupiter should be visible; at midnight BST, Perseus can be found by extending a line in the 10 o'clock direction

▲ The trail of a Perseid meteor (left) and, a rarer sight, a smoke train left behind (right)

away from Jupiter. In fact, the radiant of the Perseids is just above the main stars of Perseus; this is the area you should watch. Close to the radiant meteors will be very short, but further away meteors will be longer.

It's also useful to bear in mind that not every meteor you see will be a Perseid, so take care when identifying if what you have observed is a Perseid or not. To be sure, look at the direction the meteor took. A genuine Perseid will be travelling away from the radiant, not towards it. The length of its trail is also important; any longer meteors observed well away from the radiant should be checked by holding a straight edge, like a stick or a ruler, up to the sky to see if the trail points back towards Perseus.

Trails and trains

As the constellation of Perseus rises higher in the sky, so the number of meteors should slowly increase. There will be faint meteors, but the Perseids generally produce quite a few bright meteors and fireballs. As a meteor passes through the atmosphere, it heats up the air and creates a trail behind the meteor. For larger meteors, there can be a longer afterglow along the trail and this is called the train of the meteor. The Perseids are well known for producing bright meteors with persistent trains, the afterglow lasting some five seconds or longer. Occasionally I have seen really brilliant Perseids that leave a smoke train behind them.

Meteor showers are great to observe with friends and family for fun, their unexpected nature adding to the excitement. You can also make your meteor watch into scientifically useful data by systematically recording your observations. By studying observations of a shower, astronomers can determine if there have ▶

What to bring on a meteor watch

A few common items to have as you settle in for a night of meteor spotting

Meteor observing doesn't require any specialist equipment, but there are a few things that will make your session far more comfortable. You can of course watch the shower in an ordinary chair, but a reclining outdoor chair or a sun lounger is very helpful. You're going to be looking up at the sky for long periods, particularly later in the night when Perseus is high in the sky, and a reclining chair will prevent neck strains.

You will also need a clipboard and a copy of the BAA meteor reporting form (see overleaf). Other useful items include a red torch and some pencils or pens.

Don't forget to bring warm clothing or a blanket. It can get a bit chilly and damp in the early hours. A hot drink, some water and a snack to provide energy is also helpful.

Another thing that can be helpful is a tablet or smartphone with a planetarium app. There are a number of free examples available, such as Stellarium. You will find this is very useful when working out your limiting stellar magnitude – just open up the planetarium and look up the magnitude of the faintest star you can see with the unaided eye.

Wrap up warm, recline on a sun lounger and give your eyes time to adjust to the dark

Most planetarium software has a night mode, which will change the display to red, and don't forget to turn your screen brightness down low. Bright light, especially white light, will destroy your night vision and it can take up to 20 minutes to restore it. It's also possible to make your tablet and smartphone screen red. See the guide to changing your iPad or iPhone settings (and apps for Android devices) on our website at **bit.ly/red-screen**. Try experimenting with your phone or tablet before going out to observe.

British Astronomical Association
Meteor Section Visual Report

OFFICE USE ONLY	
Rec'd	Ack'd

Date:	2015 August 12	Observer(s):	Paul G. Abel and Pete Lawrence
Observing site:	Selsey, West Sussex UK		Sheet 1 of 3
Correspondence address:			
Observing conditions:	Recording 45% of the sky facing South. Some light haze, sky largely clear.	Stellar limiting magnitude:	5.00
Watch Times: START:	2055UT	End: 2328UT	Duration: 2 hours 33 minutes

Code No.	Time UT	Magnitude	Shower or if Sporadic	Constellation(s) in which seen	time to fade (secs)	Notes
A1	20:59	-4	PER	Ursa Major – Bootes	10s	Long train, meteor green in colour
A2	21:08	-1	PER	Ophiuchus		
A3	21:15	-1	PER	Ophiuchus		Long train
A4	21:15	0	PER	Ophiuchus		
A5	21:21	Altair: 0.8	PER	Ophiuchus		Yellowish colour
A6	21:22	0	SPORADIC	Lyra, near Vega		
A7	21:25	3.1	PER	Aquila, Serpens Cauda		
A8	21:26	2.2	SPORADIC	Ophiuchus		
A9	21:27	2	PER	Ophiuchus		Swift
A10	21:29	2.5	PER	Pegasus		
A11	21:31	0	PER	Ophiuchus		Swift pass
A12	21:34	2.9	PER	Serpens Cauda		
A13	21:35	1	PER	Cephius		
A14	21:38	3.1	PER	Pegasus		
A15	21:42	3.1	PER	Aquila		Swift
A16	21:48	1	PER	Hercules		Swift
A17	21:49	2	PER	Ophiuchus		
A18	21:52	3.1	PER	Delphinus-Aquarius		
A19	21:53	2.5	PER	Pegasus-Aquarius		
A20	21:54	1	PER	Hercules		

▲ Record your sightings of the Perseids and send the information to the BAA. Find a blank printable form in our Bonus Content online this month (see page 5)

▶ been any changes to the radiant, and see how accurate the predictions for the time of maximum activity are. All of this can be useful in determining any long-term changes to comet 109P/Swift–Tuttle, which produces the stream of particles that cause the Perseids.

Record what you see

There are particular details a recorded observation needs to have and the British Astronomical Association's meteor section has a visual reporting form that includes all of these. On the right is a completed example from a previous Perseid shower. At the top, there is information about the observer's location: name, address and observing site. There's also space to record the time you started your watch and the time it was completed (both in Universal Time: BST minus one hour), and the overall duration of your observing session. Another important detail to record is the magnitude of the faintest star you can see with your unaided eye (see What to bring on a meteor watch, page 31, for how to do this); this will give you the limiting stellar magnitude of your observing site.

PAUL ABEL/BAA, WILLIAM ATTARD MCCARTHY/ALAMY STOCK PHOTO, PETE LAWRENCE

Estimate the brightness of meteors

Being able to make a quick reckoning of meteor magnitude is a useful skill

Estimating meteor magnitudes seems straightforward on paper – just compare the meteor to a star of similar brightness – yet in practice it can be a little more challenging. Meteors rarely hang around for long, so it will often be the memory of the sighting you are comparing!

Comparing meteors you observe to the stars in this table will give you their approximate magnitude; you only need to estimate to the nearest whole magnitude. Generally, the brighter the meteor, the larger the debris that is colliding with Earth's atmosphere. If you observe a brilliant fireball as bright as Jupiter, record its magnitude as –2. If a faint meteor about as bright as Polaris (the Pole Star) is seen, record its magnitude as +2, and so on.

Remember, the fainter an object is, the higher its magnitude will be. Vega at magnitude 0 is brighter than Deneb at magnitude +1, and we can see all the way down to magnitude +6 without optical aid. Under light-polluted skies, though, we may only see down to magnitude +5.

OBJECT	APPROX. MAGNITUDE
Full Moon	–12.5
Venus	–4
Jupiter	–2
Sirius (Alpha Canis Majoris), Altair (Alpha Aquilae)	–1
Vega (Alpha Lyrae), Arcturus (Alpha Boötes), Capella (Alpha Aurigae)	0
Deneb (Alpha Cygni), Spica (Alpha Virginis), Pollux (Beta Geminorum)	+1
Polaris (Alpha Ursae Minoris), Pointers in the Plough	+2
Megrez (Delta Ursae Majoris), Alpheratz (Alpha Andromedae), Al Kab (Iota Aurigae)	+3
Eta Persei, Delta Aurigae	+4
Faintest meteors to the unaided eye	+5

▲ Perseids can be spectacularly bright – so bright that many are classed as fireballs – and range from red to green and blue

"You don't need to be a skilled astronomer to take part in a meteor watch. All that's required are a few simple items and a clear night"

We round off a great meteor year with a moonlight-free Geminids display in December

Paul G Abel is a theoretical physicist and director of the British Astronomical Association's Mercury and Venus section

The rest of the form is about the meteors you've seen. You can give each separate meteor you see a number (Code No.) and record the time you observed it, your estimate of its magnitude (see left) and the constellations it moved through. There is also a column to record whether each meteor was a Perseid or a sporadic. Finally, you can record how long it took to fade from the sky, along with any other notes about the meteor, such as whether it was a particular colour or had a long-lasting train. Once you have completed your observations, you can send your report form to the BAA meteor section; you can find the contact details on its website at **britastro.org/sections/meteor**.

This year is a good one for meteors, as several prolific, well-known showers will be unaffected by bright moonlight. Later in the year we have the Orionids, whose peak occurs on the night of 21 October, when the waxing near-first-quarter Moon sets two hours before midnight.

The famous Leonid meteor shower, which has in the past produced meteor storms, has a predicted maximum in the early hours of 18 November, when the waxing crescent Moon graciously sets early in the evening.

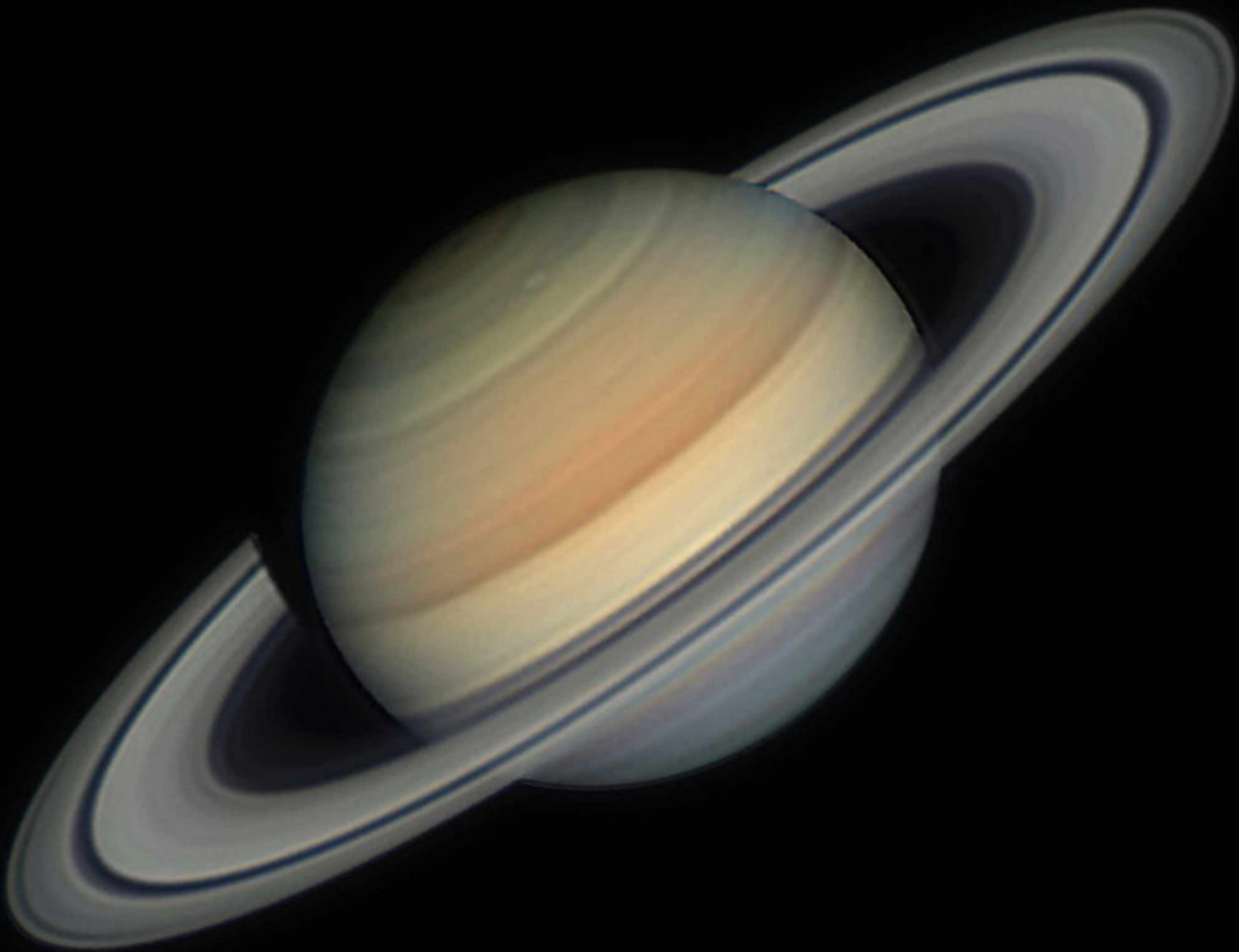
Finally, in December there is the most active of all the regular meteor showers, the Geminids, peaking on the night of 14 December, with a just-past-new Moon setting in the late afternoon. This shower has a ZHR of 100+ meteors per hour and is well known for producing slow but bright meteors and fireballs.

You don't need to be a skilled astronomer to take part in a meteor watch. All that's required are a few simple items and a clear night. If your skies are cloudy on the peak night of the Perseids, 12 August, try again on the 13th as you may still see quite a few meteors. All the observing techniques and the methods used for recording your observations in this article can be applied to other showers too.

Your observations of these showers will provide valuable information about the different meteoroid streams generated by the parent comets out in the Solar System.

▶ **Turn to page 46 for our coverage of the Perseids in the Sky Guide**

Capturing an image of Saturn – its subtle hues, captivating rings and even its encircling moons – is one of the most rewarding achievements for any skywatcher – and one anyone can try, whatever your level of experience



DAMIAN PEACH, NASA X 3

Jane Clark is a retired physicist and observatory manager for Cardiff Astronomical Society

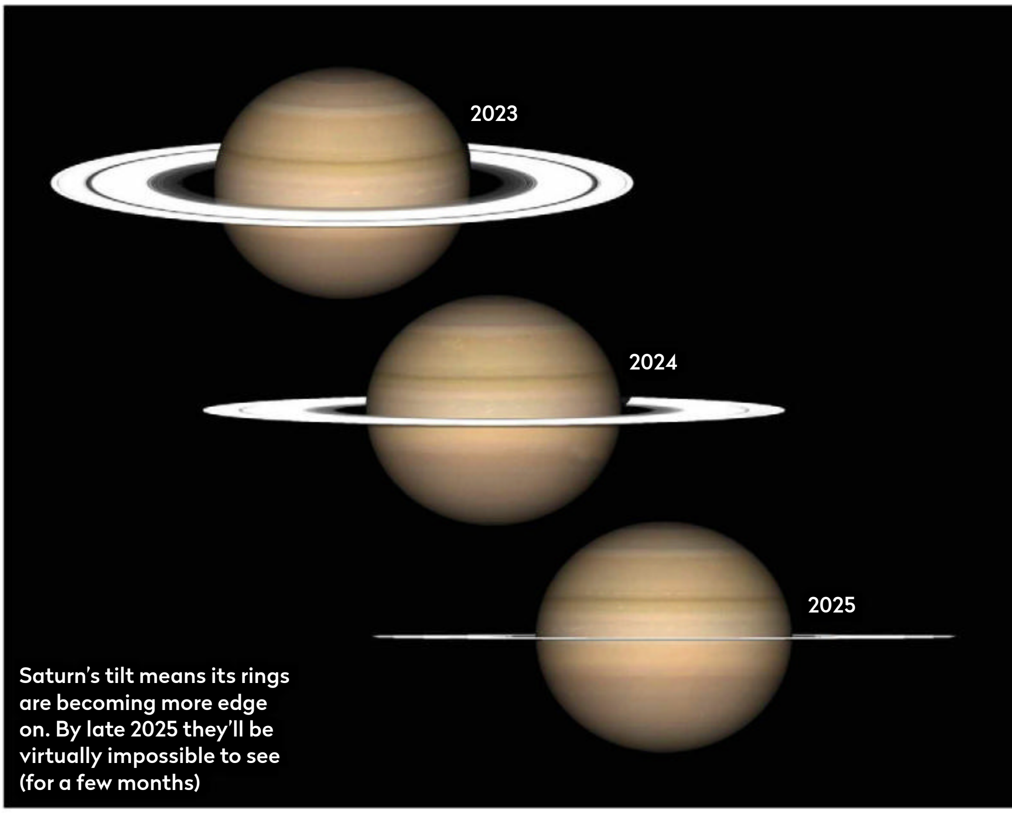
Catch Saturn's rings before they disappear

Jane Clark explains the gear, software and techniques beginners need to capture Saturn on camera before its famous rings vanish from view

There are few things quite as captivating as seeing the rings of Saturn for the first time. This month, on 27 August, the planet will reach opposition, when it lies directly opposite the Sun relative to Earth and will be at its brightest and highest, clearly visible at magnitude +0.4 and reaching around 25° in altitude from the UK. You can find Saturn in Aquarius this year and into 2024.

At the start of August, Saturn will be at its best after midnight. It rises earlier as the month goes on, becoming more of an evening object and by opposition is up all night. It will be relatively low, so we'll be looking at Saturn through more of our own atmosphere. Normally, this isn't ideal for imaging, but you'll want to catch the planet this year, as over the next few years Saturn's rings are going to disappear.

Don't worry! They'll be back. It's just that the apparent tilt of Saturn's rings varies over its 29-year orbit. This year, the rings are tilted down at a 9° angle at opposition, but next year they'll be just 3.7° and by 2025, they'll disappear into an almost imperceptible line as Earth views them edge on. After that they'll become increasingly visible as the southern pole of the planet tips towards us, reaching their maximum inclination of 27° in 2032. In a way, the rings being less tilted is an opportunity as you can watch the rapidly orbiting moons more easily.



Saturn's tilt means its rings are becoming more edge on. By late 2025 they'll be virtually impossible to see (for a few months)

Personally, I love to image Saturn, capturing the planet's bands on camera and tracking how the moons move around it. Why not make 2023 the year you get started in planetary photography and record the rings before they go? Doing so is now easier than ever, and it's even possible to capture the planets under skies with a lot of light pollution. I encourage you to have a go – the results can be extremely satisfying.

Planetary imaging takes practice. You might not immediately get prize-winning astrophotos, but with this guide you should be able to get an image you can be proud of. ▶

Recording the rings

The best way to make an image of a planet is to record it on video

There are several types of cameras you can use for astrophotography, such as DSLRs, smartphones, modified webcams and dedicated CMOS planetary cameras – all of which I'll come to in a moment – but they all follow the same basic principle of recording a video of the planet, thereby capturing thousands of images in quick succession. The weakest link in any optical setup is Earth's atmosphere and an effect known as seeing, which causes light travelling through it to shimmer. We can't predict moments of low shimmer, but videoing means we can be sure to catch them and then only use the best frames from a video during the processing stage.

Before you begin photographing the planets, it's important to make sure your optical setup is as sharp as it can be. Make sure refractors are well-collimated if needed and then focus using a nearby star. You may want to consider using tools like a Bahtinov mask to make sure your optics are pin-sharp.

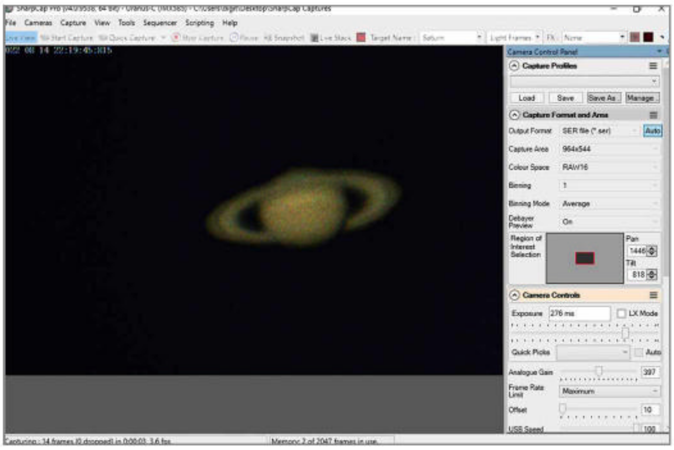
There are two main planetary image-capture programs nowadays: SharpCap and FireCapture. FireCapture is freeware. SharpCap has a pro version, currently £12 per year, with some handy extensions such as a method of polar alignment for equatorial mounts, but there is also a stripped-down, free version.

Planetary cameras are generally supported via their own drivers. For webcams, you may need to set up a driver using an app called the ASCOM platform, obtainable for free from **ascom-standards.org**. ASCOM drivers can do all sorts of things, from controlling filter wheels to managing electric telescope focusers, and ASCOM's capability is increasing all the time.

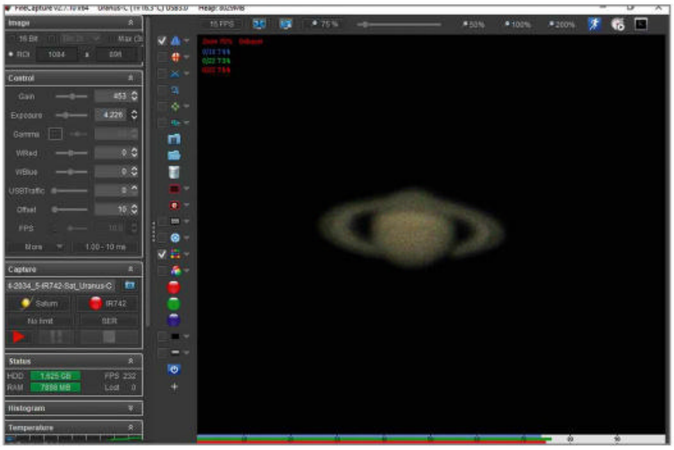
With all cameras, it's best to very slightly overexpose the image and pull back during processing, using the 'gamma' control. Be sure to capture the planet in a movie format – the most commonly used are AVI and SER.

You'll need pin-sharp focus before you start – a Bahtinov mask will help. You can make your own by following our guide at bit.ly/DIYbahtinov

SharpCap is a handy program to help you capture the planet – and it's free



▲ The real-time live view in SharpCap Pro, showing the camera control panel where you can set exposure times and more



▲ FireCapture in action. It has a similar interface, allowing you to adjust the gain, gamma and exposure settings for your camera

MARK PARRISH, STEVE MARSH, PETE LAWRENCE X 3, JANE CLARK X 2

▶ Replace the lens of your trusty DSLR with a adaptor that slots into the telescope's focuser. This one has a UV/IR blocking filter on the front

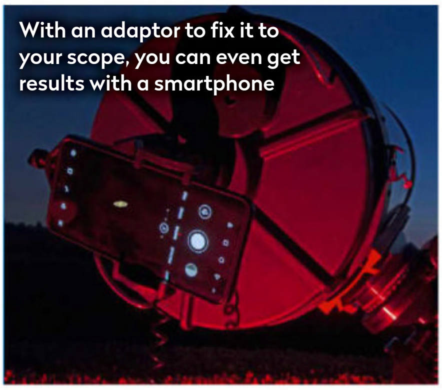
Smartphones and DSLRs

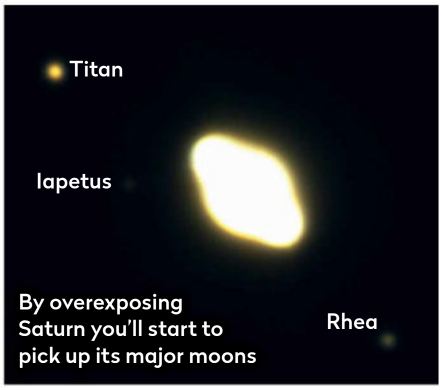
You can have a go at planetary photography using equipment you may already own

It's possible to take planetary photographs with a DSLR or even a smartphone, with the help of adaptors. DSLR adaptors fit directly into your telescope's eyepiece holder, while smartphones will also require an eyepiece as they hold your phone's camera over it, allowing you to capture a view similar to what you'd see with your eyes. Be sure to align the smartphone holder precisely or the brightness of the image will fall off catastrophically. The camera needs to be centred over and laid flat against the eyepiece so that the edges of your view through the eyepiece appear sharp.

These kinds of images are great if you're just looking for a quick snap to remember the night or want to test the waters of planetary photography, but they'll be of limited quality. Although DSLRs can be excellent for serious deep-sky photography, I have never seen detailed planetary images taken with either DSLRs or mobile phones.

You should be able to see the outline of the planet, the rings and perhaps Saturn's largest moon Titan, but that's about it. If you overexpose, you can pick up more moons, so long as you don't mind the planet being whited out – a technique you can use with any of the cameras described in this article.


With an adaptor to fix it to your scope, you can even get results with a smartphone



By overexposing Saturn you'll start to pick up its major moons

Modified webcams

A little DIY can turn the humble webcam into a planetary powerhouse

One budget-friendly option to capture good planetary images is to use an adapted webcam, which can cost as little as £35, though it will need to be connected to a computer to operate and collect data. Many cameras are suitable, for example the Logitech C270 or Microsoft LifeCam. Preferably, you'll want something that shoots in AVI format, though other acceptable formats are SER and MPEG files. If yours only does MOV files, you will need to buy a program to convert them. It's also wise to check whether your image-capture software supports your particular model.

To adapt the camera, carefully prise off the front of the housing with a knife or a screwdriver and unscrew the lens. In its place, attach a 1.25-inch telescope-eyepiece-to-webcam adaptor ring, which needs to be purchased separately but will make keeping the camera in position in your telescope's draw tube much easier.

Cover over with tape any LEDs which might affect your imaging, then close up the front of the camera. You can usually use at least part of the original housing to do this, then seal any gaps using waterproof glue or tape to prevent dew falling into the camera. ▶

▲ With some DIY adjustment, HD webcams like the Logitech C270 (top) and Microsoft LifeCam (bottom) are a cheap option for imaging planets

CMOS cameras

Dedicated planetary cameras yield the best results and needn't break the bank

Low-cost, high-speed CMOS cameras are well-suited to astrophotography and have come down tremendously in price over the last few decades. You can now get an excellent one for under £300. I have an ASI662MC from ZWO's almost bewilderingly large range of planetary cameras. Other brands you may want to look at are the Atik GP colour camera and the Opticstar range, which have lower frame rates, but the latter are around half the price of ZWO models.

You can either use a colour camera or a monochrome camera with filters. I strongly favour colour cameras because the images are easier to process. Plus, the fickle British climate does not always allow time to take four separate luminance, red, green and blue images, and the filter wheels required to make the rapid filter changes are expensive.

But is it worth buying a separate planetary camera if you already have a cooled colour camera for deep-sky work? The answer is simple: you can obtain much higher frame rates with purpose-built planetary cameras. My ZWO ASI662MC can shoot hundreds of frames per second. My cooled deep-sky camera, a ZWO ASI2600MC, can only manage a few frames per second. It's designed for long exposures, not short ones. Fast cameras can capture planets even if there's a lot of cloud around. At 100 frames per seconds, you can shoot 6,000 frames in a minute, which is great for 'snatching' images in between the clouds.

Specialist planetary cameras do need a laptop or PC to control them and to store their image data. I used to use a laptop, but as I now have my own observatory, I use a desktop PC with lots of USB ports. ZWO now offers the ASiair – essentially a Raspberry Pi in a fancy cover – which will elegantly serve this purpose if you want a mobile rig. It is controlled from your smartphone and costs about £330. Whatever you use, make sure you have lots of digital storage space to keep your 5,000–10,000-frame movies.

"You can obtain much higher frame rates with planetary cameras – mine shoots hundreds of frames per second"

▲ Jane's observatory setup with ZWO ASI662MC (right), Celestron scope and driven mount all linked to her PC

◀ Jane's configuration for photographing planets

JANE CLARK X 7

Processing your images

Combine 1,000 images into just one to create stunning planetary photographs

Once you have your first movie, you will quickly notice how seeing makes the sharpness of the image come and go. Fortunately, you should have plenty of frames, ideally a few thousand. Software can select the best of these, then combine them together using a technique called 'stacking'.

Stacking combines your best frames to create a single image with a total exposure time of all the frames you end up using. I may, for example, stack 10,000 frames and, because of poor seeing, only keep 1,000. If each exposure is 1/100 of a second, I effectively have a 10-second exposure. Those 10 seconds weren't continuous, but the best frames gathered during the periods of good seeing; the remaining 90 seconds is thrown away.

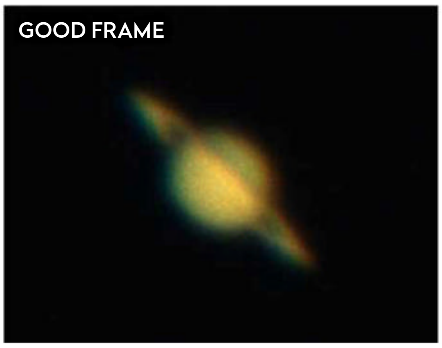
The best software for this is AutoStakkert!, which you can download from **www.autostakkert.com**. It's unbelievably easy to use and a huge improvement on earlier stacking programs. The only decision you need to make is how many frames to keep.

Remember to select 'RGB align', which compensates for Earth's atmosphere behaving like a prism and separating these colours. This is especially true if the planet is low in the sky, but I always use it, even for high-altitude planets.

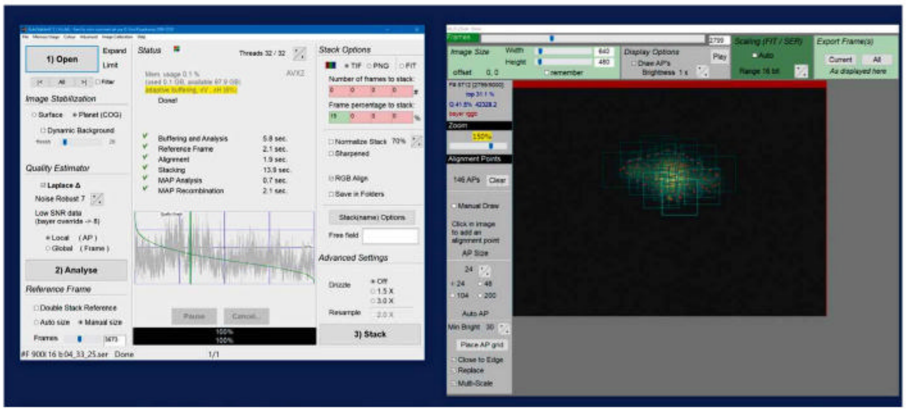
Once stacked, you can output a variety of file types. I use TIFF files, which can be fed to the next stage: sharpening. For this I use freeware called RegiStax (**www.astronomie.be/registax**). RegiStax can also select lucky frames and stack them, but AutoStakkert! is considered better and faster. RegiStax, however, has a wavelet function to sharpen up images. You can also use the waveSharp package or AI sharpening tools such as Topaz Sharpen AI ($80). There are many options for sharpening and in my experience no two images require the same treatment. You'll probably need to experiment, but there are lots of great guides out there. I learned a lot from the planetary imaging playlist at **youtube.com/@wwgeb**.

"Stacking combines the best frames to create a single image with a total exposure time of all the frames you end up using"

You can find a more in-depth guide to the whole stacking procedure in our Astrophotography Processing article on **page 78**, but once you've completed this part, you're done! All you need to do is sit back, admire your image of Saturn and start thinking about which planet you want to image next.



▲ **The stacking process sifts through all your frames, selects the best (you choose what percentage), then stacks them into one image**



▲ **AutoStakkert! takes the strain, analysing your frames and then stacking them for you**

▲ **The author's exquisitely coloured Saturn and bright rings, captured earlier this year**

The great American eclipses

Tens of millions will experience two well-placed eclipses: a 'ring of fire' annular eclipse in October and a total eclipse next April

In a once-in-a-lifetime spectacle, two solar eclipses are about to cross over the USA. **Jamie Carter** has the details

Eclipses are one of nature's most mesmerising spectacles. Eclipse-chasers are often willing to fly half-way around the world to remote, hard-to-reach locations just for the chance to see the phenomenon. The coming months, however, mark a unique opportunity as not just one but two eclipses are set to cross one another over North America.

On 14 October 2023, a 'ring of fire' annular eclipse will pass across 10 countries, with a long section of the path running straight through the USA. But this will just be a warm-up to the second event 177 days later on 8 April 2024, when a total solar eclipse will pass across the USA, Mexico and Canada, with an estimated 32 million people living inside the path of totality. There's even a region in Texas – including much of San Antonio – that will see both.

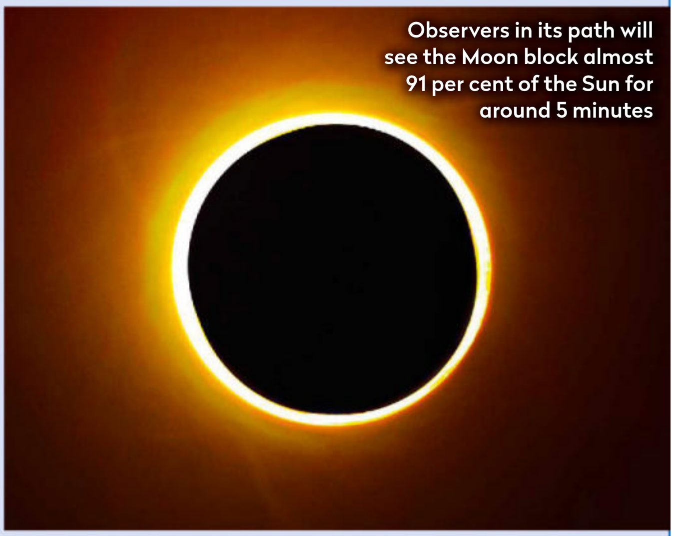
This pair of eclipses will be the most accessible in decades. If you're thinking of making the journey to see either, there's no shortage of sites to pick, as they both trace long paths across the USA.

Annular eclipse, 14 October 2023

Ten countries lie in the path of the ring of fire

The Moon's elliptical orbit means sometimes it blocks all but the outer edge of the Sun, leaving an annulus (ring) of light: an annular solar eclipse. You'll need suitable solar filters to view it, but it's a sight well worth making the journey to behold.

During October's eclipse, the Moon will cover almost 91 per cent of the Sun for up to 5 minutes and 17 seconds. The path of annularity, where you'll see the 'ring of fire', will touch land in Oregon at 09:13 PDT (16:13 UT) moving southwest until it leaves Texas at 12:03 CDT (17:03 UT), before passing over Mexico, Belize, Guatemala, Honduras, Nicaragua, Costa Rica, Panama, Colombia and Brazil, where it will finally end at 16:48 BRT (19:48 UT). The path of annularity will be up to 225km wide and the longest eclipse will be just off the coast of Nicaragua in the Gulf of Mexico. This will be far more accessible than the four other 'ring of fire' eclipses this decade, in the Pacific, Patagonia, the Amazon and Siberia, so it's one to take advantage of.



Observers in its path will see the Moon block almost 91 per cent of the Sun for around 5 minutes

NATALIE BEHRING/STRINGER/ISTOCK/GETTY IMAGES, ALBERTO BUZZOLA/ISTOCK/GETTY IMAGES, RYAN HODNETT, SAN FRANCISCO CHRONICLE/HEARST NEWSPAPERS VIA GETTY IMAGES, MAP BY PAUL WOOTTON

Total eclipse, 8 April 2024

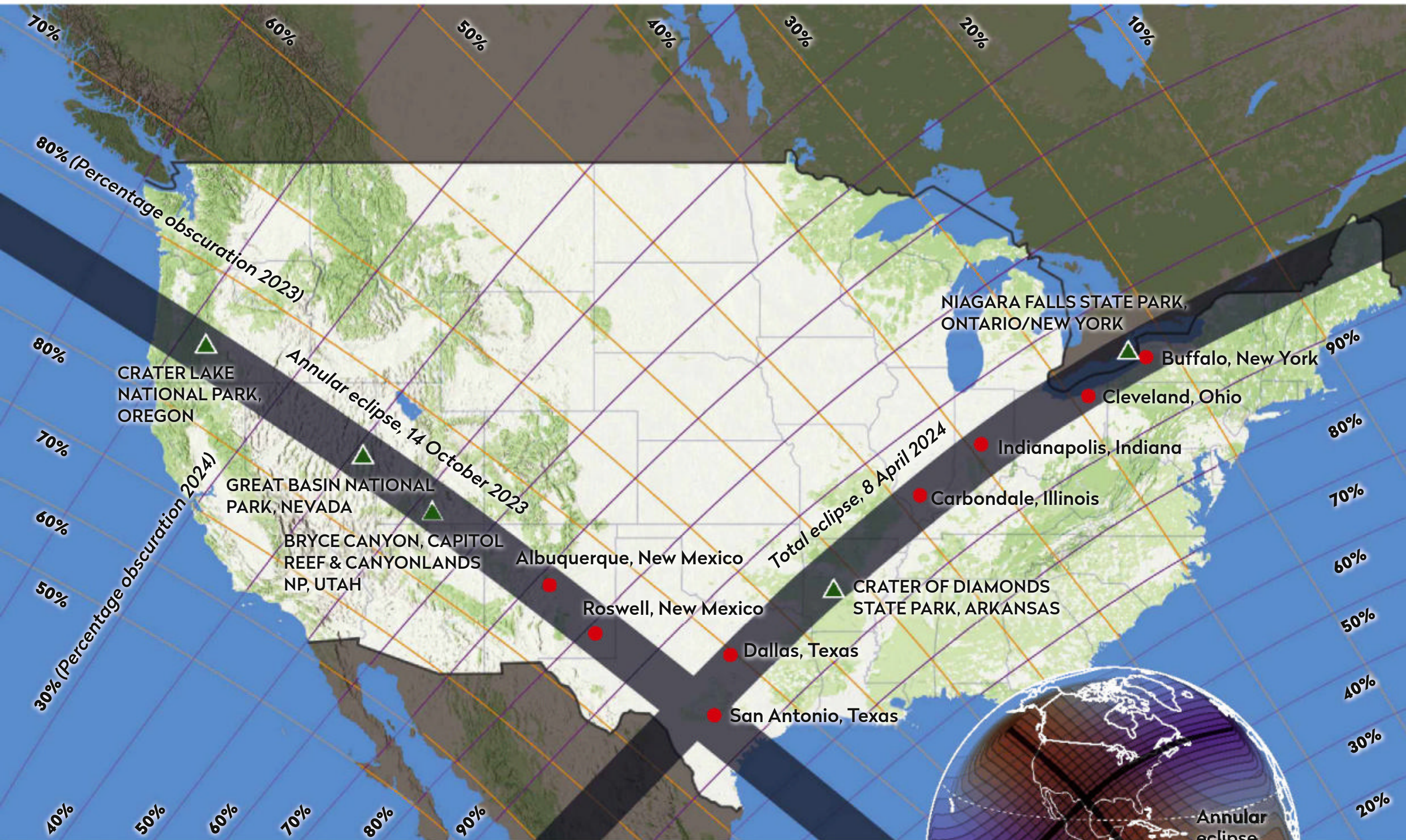
Millions of people are expected to turn out to see the eclipse

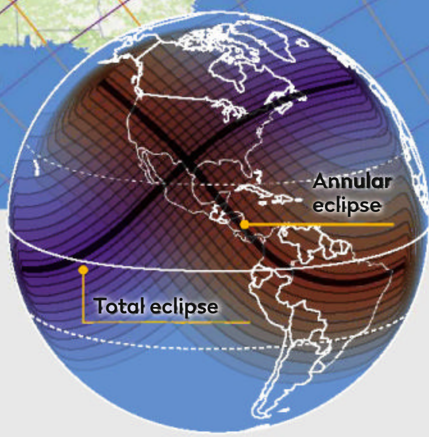
This total solar eclipse is already being called the Great North American Eclipse and is expected to be one of the most-viewed eclipses in recent history. The path of totality will be around 190km wide, with a maximum duration of 4 minutes and 28 seconds visible in Durango, Mexico. Totality will be seen first in Mazatlán on the Pacific coast at 11:09 MST (17:09 UT), crossing into the US in Texas at 13:27 CDT (18:27 UT), moving up through the country, eventually crossing into Canada. The Moon's central shadow will leave land at South Bird Island, Newfoundland at 17:13 NDT (19:43 UT).

The closer you stand to the centre of the path of totality the longer you'll be able to see totality. But you'll also want to consider the weather, and sites further southwest have a better chance of clear skies, with Mexico having the clearest skies for the time of year.

The total eclipse's last touching point is South Bird Island, Newfoundland

Huge numbers will be cast into eerie twilight as only the Sun's corona will remain





Where you'll get the best view

The eclipses will be visible anywhere in their paths of totality or annularity, but there are many iconic sites you might want to visit. Here are a selection of parks and cities in the paths (including UFO paradise Roswell, New Mexico and Carbondale, Illinois, which also saw the 2017 eclipse).

KEY

- ▲ NATIONAL/ STATE PARK
- ● Cities along eclipse paths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16-PAGE CENTRE PULLOUT

BBC Sky at Night MAGAZINE

The Sky Guide

AUGUST 2023

THE PERSEIDS ARE COMING

With no Moon to interfere, this year's display should be stunning, peaking for the UK on the nights of 12–14 August

TOUR THE MILKY WAY

Six binocular sights to find near Sagittarius

SUPER BLUE MOON MONTH

See two perigee full Moons shine at their biggest and brightest

PETE LAWRENCE

About the writers

Astronomy expert **Pete Lawrence** is a skilled astro imager and a presenter on *The Sky at Night* monthly on BBC Four

Steve Tonkin is a binocular observer. Find his tour of the best sights for both eyes on page 54

Also on view this month...

- ✦ Venus reaches inferior conjunction
- ✦ Deep-sky targets around Cygnus
- ✦ Splendid Saturn at opposition

Red light friendly

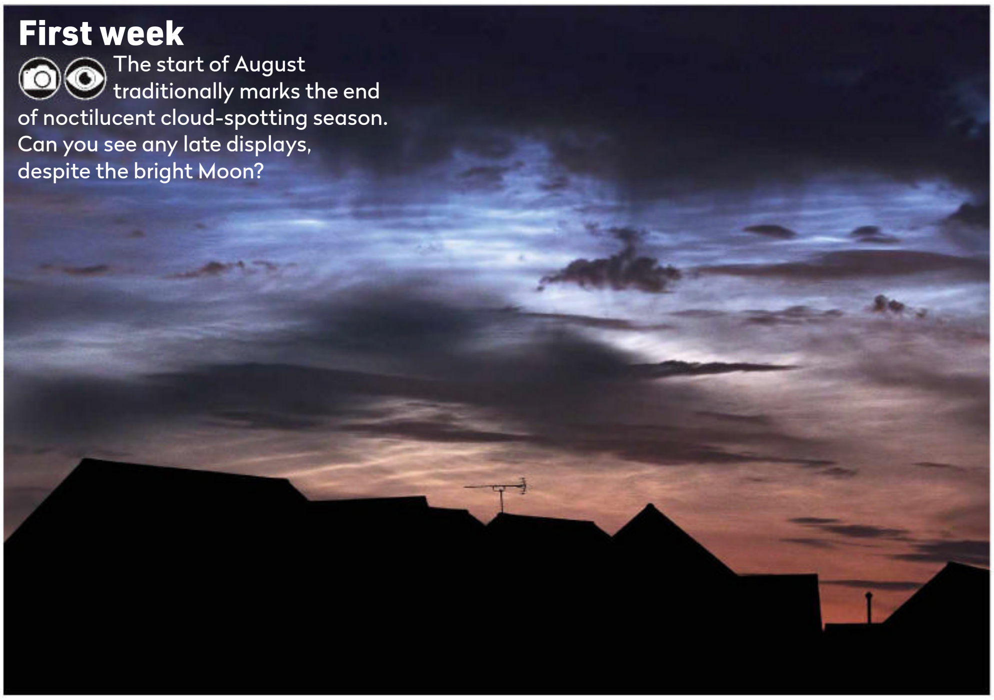
To preserve your night vision, this Sky Guide can be read using a red light under dark skies

Get the Sky Guide weekly

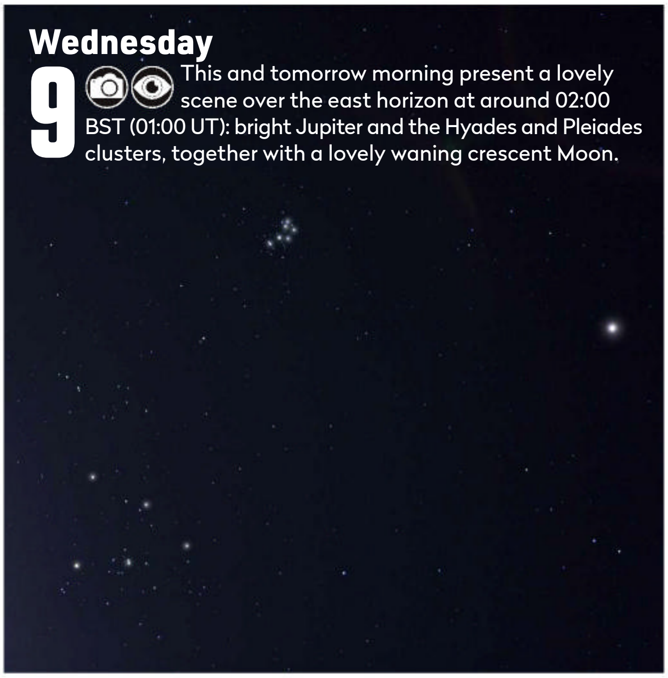
For weekly updates on what to look out for in the night sky and more, sign up to our newsletter at **www.skyatnightmagazine.com**

AUGUST HIGHLIGHTS
Your guide to the night sky this month

All month
Comet C/2020 V2 ZTF is currently around ninth magnitude and in the region of sky just south of Uranus and Jupiter.

First week

The start of August traditionally marks the end of noctilucent cloud-spotting season. Can you see any late displays, despite the bright Moon?

Friday 4
Venus is at 3% phase, at 55-arcseconds apparent diameter.

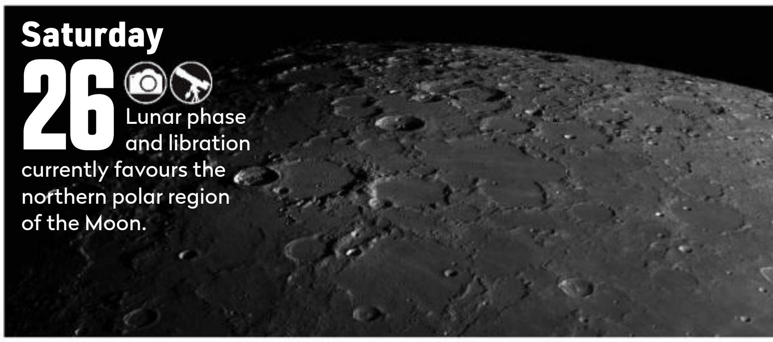
Wednesday 9

This and tomorrow morning present a lovely scene over the east horizon at around 02:00 BST (01:00 UT): bright Jupiter and the Hyades and Pleiades clusters, together with a lovely waning crescent Moon.

Thursday 10 ▶
Mercury reaches greatest eastern elongation, the mag. +0.4 planet separated from the Sun by 27.4°. Visible in the evening sky, it's low and tricky to see.

Sunday 13
Venus reaches inferior conjunction at 12:15 BST (11:15 UT), when it passes 7.7° south of the Sun's centre. With extreme care, this can be observed. See page 55 for more.

Tuesday 15
Venus has reached a phase of just 0.1% and is currently presenting an apparent diameter of 57 arcseconds.

Family stargazing
The peak of the Perseid meteor shower occurs on the nights between 12–14 August. This is a great event for youngsters to enjoy. Suggest getting some sleep earlier in the day though! Set out something to lie on in the darkest part of your garden – a sunbed is perfect. Aim to observe from 23:00 BST until 03:30 BST. If you can't do the whole period, from 01:00 until 02:00 BST is recommended. Wrap up warm and avoid any lights which will affect your night vision. Look up to a height around two-thirds up the sky; any direction will do.
www.bbc.co.uk/cbeebies/shows/stargazing

Saturday 26

Lunar phase and libration currently favours the northern polar region of the Moon.

PETE LAWRENCE X 9

Tuesday 1

Today's full Moon occurs at 19:31 BST (18:31 UT), near lunar perigee on 2 August. It is the first of two full Moons this month, both of which are perigee full Moons.

Wednesday 2

Venus is at 4% phase with a 54-arcsecond apparent diameter.

Sunday 6

Venus is at 2% phase with a 56-arcsecond apparent diameter.

Tuesday 8

Venus has reached a phase of just 1% and is currently presenting an apparent diameter of 56 arcseconds.

Saturday 12

Perseid meteor activity peaks in the early hours of 13 August. This year, the Moon will not give any interference and, with clear skies, it should be a great display.

Thursday 24

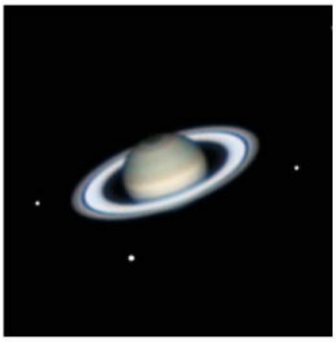
This evening, as it approaches its setting point, the 54%-lit waxing gibbous Moon sits 3.2° west of mag. +1.0 Antares (Alpha (α) Scorpii).

Friday 25

Venus has reached a phase of 5% and is currently presenting an apparent diameter of 54 arcseconds.

Sunday 27

Saturn reaches opposition today. It's currently shining at mag. +0.3 and from the centre of the UK reaches an altitude of 25° when due south.



Thursday 31

Today sees the second full Moon of the month which, although not technically correct, is known in popular culture as a Blue Moon. As it is also a perigee full Moon, or supermoon, it has gained the name Super Blue Moon.

NEED TO KNOW

The terms and symbols used in The Sky Guide

Universal Time (UT) and British Summer Time (BST)
Universal Time (UT) is the standard time used by astronomers around the world. British Summer Time (BST) is one hour ahead of UT

RA (Right ascension) and dec. (declination)
These coordinates are the night sky's equivalent of longitude and latitude, describing where an object is on the celestial 'globe'

Family friendly
Objects marked with this icon are perfect for showing to children

Naked eye
Allow 20 minutes for your eyes to become dark-adapted

Photo opp
Use a CCD, planetary camera or standard DSLR

Binoculars
10x50 recommended

Small/ medium scope
Reflector/SCT under 6 inches, refractor under 4 inches

Large scope
Reflector/SCT over 6 inches, refractor over 4 inches

GETTING STARTED IN ASTRONOMY

If you're new to astronomy, you'll find two essential reads on our website. Visit **bit.ly/10_easylessons** for our 10-step guide to getting started and **bit.ly/buy_scope** for advice on choosing a scope

THE BIG THREE The top sights to observe or image this month

DON'T MISS

Perseids 2023

BEST TIME TO SEE: Nights of 12/13 and 13/14 August

The annual Perseid meteor shower reaches peak activity mid-August. The quality of the display that we'll see during the peak is determined by two factors: the weather and the Moon.

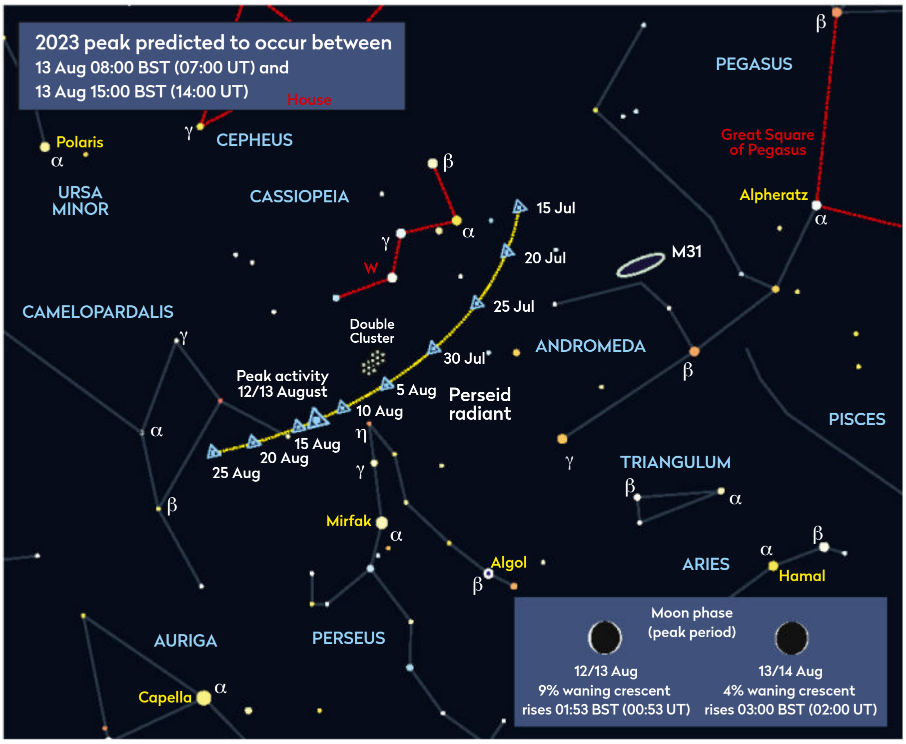
You can't do a great deal about the former, except monitor forecasts and relocate to a clear site if it looks like your location is going to be poor. The Moon is easier to predict; it's either going to be a nuisance like it was in 2022, or it's not.

This year, the Perseid meteor shower peak is predicted to occur in the early hours of 13 August, meaning the best nights will be 12/13 and 13/14 August. If you want to watch the build up to and from the peak, the nights from 10/11 to 15/16 August are worth considering too. But what about that Moon? Well, it will be at last quarter phase on 8 August and at new Moon on 16 August. This means that over the date range we've given, there will be no moonlight interference this year.

Perseid activity is modelled to produce a sharp peak centred around a specific time. Perseid meteors occur when Earth passes through the dust spread around the orbit of comet 109P/Swift–Tuttle. The specific time of the peak represents when we are in the densest part of the dust stream. The actual peak tends to show significant enhanced activity for a period of around 16 hours centred on that peak – this is the width of the peak beyond which activity falls to less than half the actual peak value.

However, it's not as simple as this, because activity appears naturally enhanced for the Perseids when the shower radiant in Perseus is higher in the sky and after midnight UT from the UK. The night of 12/13 August should show best activity, especially into the morning of the 13th. The night of 13/14 August should be good too, but on the evening of 13 August, as meteor rates naturally fall, the shower radiant will be lower and it'll be best before midnight UT. During the morning of 14 August, the rates should naturally have fallen below half their predicted peak.

Observing the Perseids is easy. Simply find a dark location away from stray light. Make yourself comfortable, looking at an altitude around 60° in any direction. Looking northwest towards Perseus delivers shorter meteors which are easier to line up with the radiant. Longest trails are visible at 90° to the radiant. At 180° from the radiant, trails shorten again, appearing to converge on what's known as the anti-radiant.



▲ With no moonlight to spoil things, get ready for an impressive Perseid display mid-month

If you're lucky enough to see a Perseid fireball, it's a sight not quickly forgotten

ALL PICTURES: PETE LAWRENCE

Venus at inferior conjunction

BEST TIME TO SEE: 1–13 August

Venus reaches solar conjunction on 13 August. This is an inferior conjunction, the moment when Venus lines up with the Sun on the Earth side of its orbit. The alignment isn't precise and in 2023 Venus ends up passing south of the Sun. Some inferior conjunctions are closer than others. The inferior conjunction on 13 August brings Venus to 7.7° from the Sun's centre at 12:15 BST (11:15 UT) and with great care and pre-existing knowledge of how to observe such an event, Venus can still be picked up using a camera.

The dangers of observing this close to the Sun are obvious and it's important not to push your limits if you're not sure what you're doing. Pointing a telescope this close to the Sun runs the risk of light passing down the optical tube. If this happens, the scope may be damaged. You should certainly not attempt to view this close to the Sun visually, only via a camera with a live feed.

▲ Images from 2007 showing an ultra-thin crescent Venus passing south of the Sun

On 1 August, Venus sits 18.6° from the Sun but isn't visible in the evening sky after sunset. Therefore it's necessary to hone your skills for locating the planet during the day (see **page 55** for more on how to go about this).

On this date, Venus shows as a slender 5%-lit crescent, 53 arcseconds across. One week later on 8 August the separation from the Sun will have decreased to 10.4°, Venus showing as a very delicate 1%-lit crescent with an apparent diameter of 57 arcseconds. At inferior conjunction on 13 August, Venus will be showing a phase of 0.9%, now appearing 58 arcseconds across.

An interesting phenomenon occurs when Venus's separation from the Sun decreases below 12°, the horns of the planet's delicate crescent appearing to extend further than they should to form what are known as cusp extensions.

A Super Blue Moon

BEST TIME TO SEE: 1/2 August and 30/31 August

The Moon reaches perigee on 2 August at 06:52 BST (05:52 UT), when its elliptical orbit brings it closest to Earth. Full Moon is on 1 August at 19:31 BST (18:31 UT), 11 hours and 21 minutes before perigee, making this a perigee full Moon, also known as a proxigean Moon or a supermoon. It appears larger and brighter than average, although in practice it won't look a lot different to the ones that precede or follow it.

The full Moon on 1 August means there's room for a second in August. This occurs on 31 August at 02:35 BST (01:35 UT), 9 hours and 44 minutes after perigee on 30 August at 16:51 BST (15:51 UT), making it also a perigee full Moon and the closest of the four occurring this year. As the second full Moon in a month, it's known as a Blue Moon, so this supermoon is dubbed a Super Blue Moon.

A perigee full Moon or supermoon (left) is 14 per cent larger and 25 per cent brighter than an apogee full Moon (right), although the differences aren't obvious to the naked eye

A Blue Moon being 'the second full Moon in a month' isn't what the term used to mean, but a misinterpretation that appeared in print in 1946. As it's easier to understand than the original 'third full Moon in a season of four' meaning, it stuck.

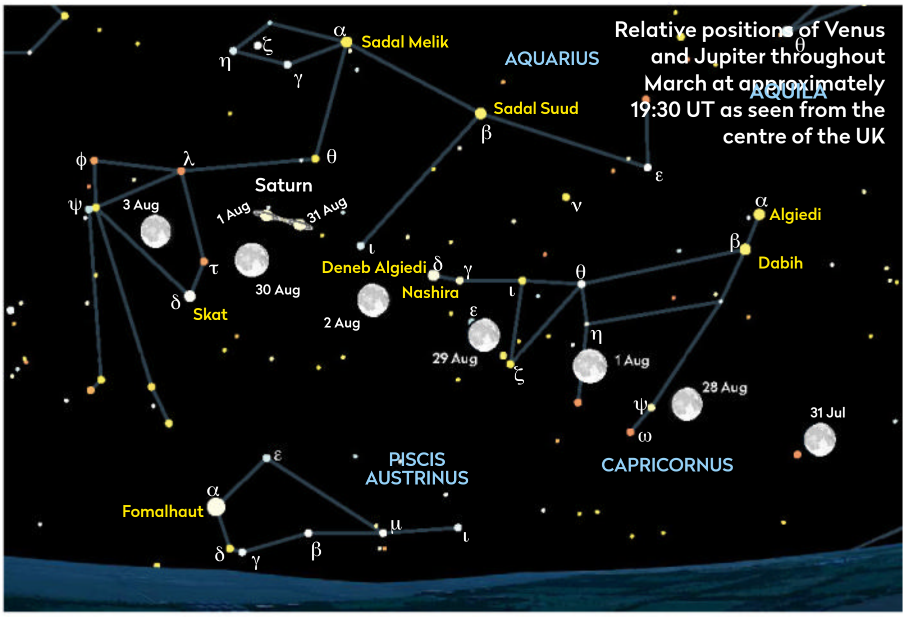
Ironically, full Moons at this time of year tend to rise at a fairly leisurely pace, staying at low altitude. Consequently, the 31 August Blue Moon is more likely to appear orange than blue!

THE PLANETS Our celestial neighbourhood in August

PICK OF THE MONTH

Saturn

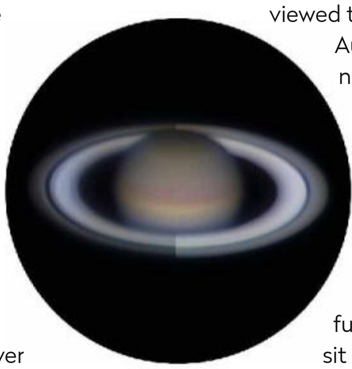
Best time to see: 27 August, from 01:18 BST (00:18 UT)
Altitude: 25°
Location: Aquarius
Direction: South
Features: Subtle banded atmosphere, rings, moons
Recommended equipment: 75mm or larger



▲ Excellent views of Saturn this month, including close meetings with two full Moons

Saturn reaches opposition on 27 August and this month the view is excellent. On 1 August, it reaches its highest position under relatively dark skies, a situation that only improves throughout the month. At its highest, it appears 25° up as seen from the centre of the UK. Although still rather low, this is a big improvement over recent years and under good seeing should allow decent views of the planet and its rings. At opposition, Saturn will shine at magnitude +0.3.

A few days before opposition, the planet's distinctive rings should appear to exhibit a subtle brightening, caused by what's known as the opposition effect. When viewing Saturn away from opposition, the shadows cast by the myriad of ring particles are visible. At opposition, the shadows are reduced to a minimum, making the rings appear brighter. The opposition effect brightening continues until opposition. Afterwards, the rings slowly dim back to their normal brightness over the course of a number of days. During August, the planet's axis is tilted towards Earth by a little over 8°, the north pole being the one tilted towards us. The rings are tilted similarly and appear relatively thin as a result when viewed through the eyepiece.



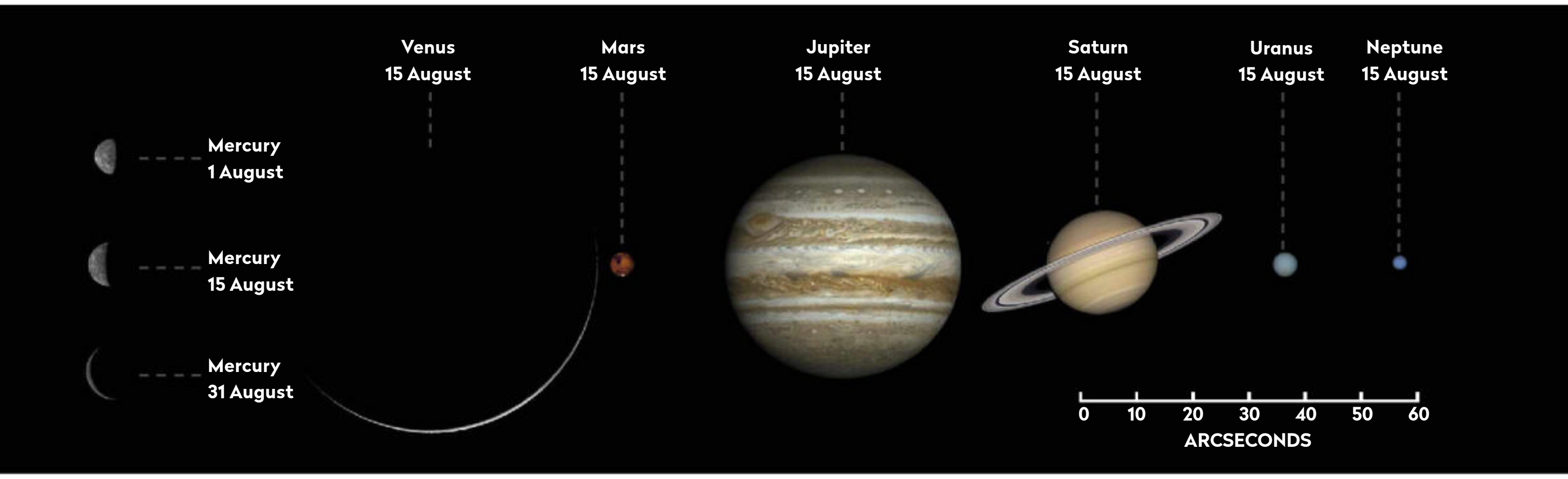
▲ Saturn's rings show a subtle brightening at opposition (right half)

PETE LAWRENCE X 2

August's relatively short nights mean that Saturn is visible all night long throughout the month. A just-past-full Moon sits close to the planet on the nights of 2 and 3 August. On the evening of 31 August, a second full Moon occurs. This will sit really close to Saturn and after both objects rise, Saturn appears 3.3° northwest of the Moon's centre.

The planets in August

The phase and relative sizes of the planets this month. Each planet is shown with south at the top, to show its orientation through a telescope



Mercury

Best time to see: 1 August, 30 minutes after sunset
Altitude: 2° (very low)
Location: Leo
Direction: West
An evening planet, badly placed as it reaches greatest eastern elongation on 9 August when it shines at mag. +0.4 and sets 40 minutes after sunset. Its position deteriorates further throughout August.

Venus

Best time to see: 31 August, from 40 minutes before sunrise
Altitude: 8° (low)
Location: Cancer
Direction: East
Venus is technically an evening object during the first half of August, but it isn't visible as it sets before the Sun. It reaches inferior conjunction on 13 August when it lines up with the Sun, passing 7.7° south of the Sun's centre. Its phase decreases from 5% on 1 August to 0.9% on 13 August. To see Venus at this time, it needs to be located during the day. Great care is needed due to the proximity of the Sun. It is not safe to view visually; a camera should be used. After inferior conjunction, Venus re-emerges into the morning sky and should become visible again from the start of the last week in August. By 31 August, mag. –4.3 Venus rises 1 hour 50 minutes before sunrise.

Mars

Best time to see: 1 August, 50 minutes after sunset
Altitude: 2° (very low)
Location: Leo
Direction: West
At the start of August, Mars shines at mag. +1.8 but is very hard to see, low above the western horizon as the sky darkens. A slender 5%-lit waxing crescent Moon sits 2.8° right and slightly up from Mars on 18 August, but even seeing the Moon will be challenging!

Jupiter

Best time to see: 31 August, from 04:45 BST (03:45 UT)
Altitude: 51°
Location: Aries
Direction: South
A brilliant morning planet shining at mag. –2.3 in southern Aries. Against a dark sky, Jupiter reaches 23° altitude on 1 August, but by the end of the month this improves greatly, reaching an altitude of almost 50° as seen from the centre of the UK. The last quarter Moon appears nearby on the morning of 8 August.

Uranus

Best time to see: 31 August, 04:00 BST (03:00 UT)
Altitude: 47°
Location: Aries
Direction: Southeast
On 1 August, mag. +5.8 Uranus reaches 20° altitude under dark skies, 9.1° east-northeast of mag. –2.2 Jupiter. As they rise, a 44%-lit waning crescent Moon sits 1.5° north of Uranus just before midnight BST on 8 August. By the end of August, Uranus reaches 50° altitude under darkness, Jupiter closing the gap between both worlds. Shining at mag. –2.5, Jupiter sits 7.6° west-southwest of mag. +5.7 Uranus on 31 August.

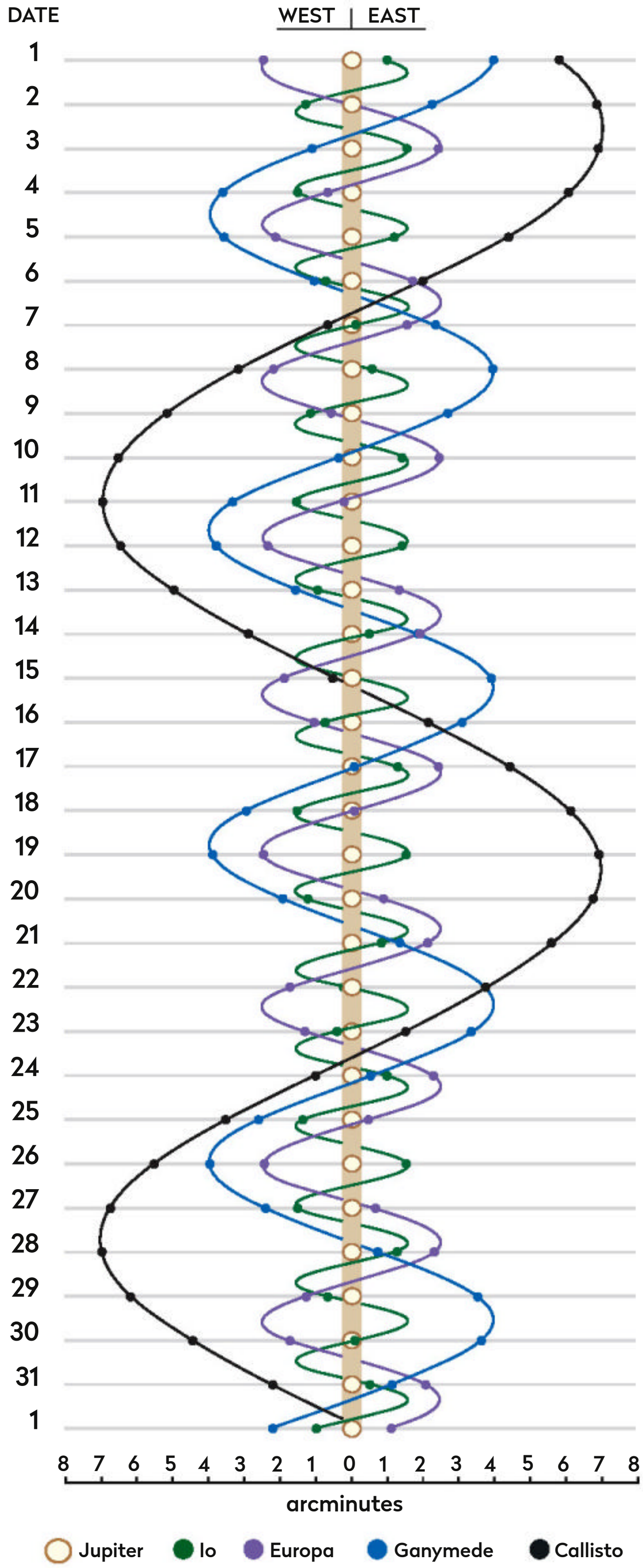
Neptune

Best time to see: 31 August, 02:20 BST (01:20 UT)
Altitude: 35°
Location: Pisces
Direction: South
Neptune reaches 35° altitude when due south, under darkness from mid-month onwards. At mag. +7.8, optical assistance is required.

MORE ONLINE
Print out observing forms for recording planetary events

JUPITER'S MOONS: AUGUST

Using a small scope you can spot Jupiter's biggest moons. Their positions change dramatically over the month, as shown on the diagram. The line by each date represents 01:00 BST (00:00 UT).



THE NIGHT SKY – AUGUST

Explore the celestial sphere with our Northern Hemisphere all-sky chart

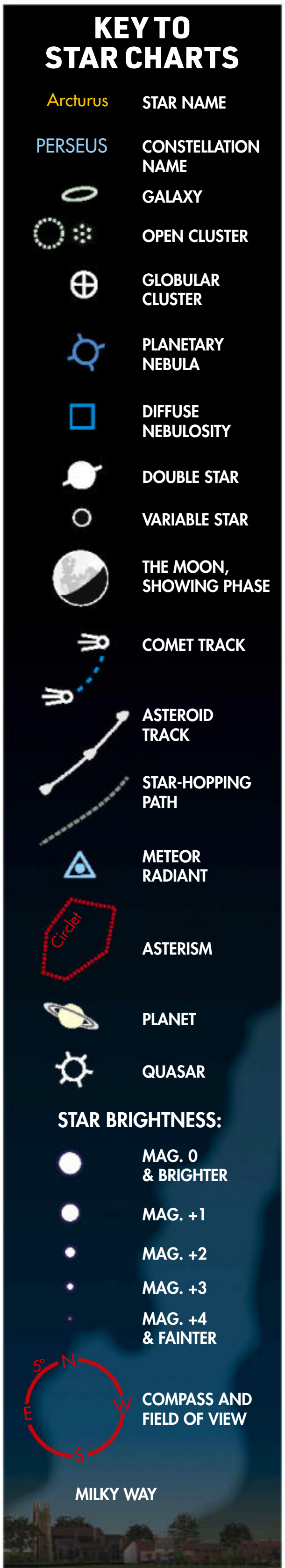


CHART: PETE LAWRENCE

When to use this chart

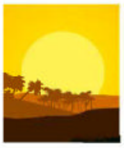
1 August at 01:00 BST
15 August at 00:00 BST
31 August at 23:00 BST

On other dates, stars will be in slightly different positions because of Earth's orbital motion. Stars that cross the sky will set in the west four minutes earlier each night.

How to use this chart

1. Hold the chart so the direction you're facing is at the bottom.
2. The lower half of the chart shows the sky ahead of you.
3. The centre of the chart is the point directly over your head.

Sunrise/sunset in August*



Date	Sunrise	Sunset
1 Aug 2023	05:25 BST	21:06 BST
11 Aug 2023	05:42 BST	20:47 BST
21 Aug 2023	06:00 BST	20:26 BST
31 Aug 2023	06:17 BST	20:03 BST

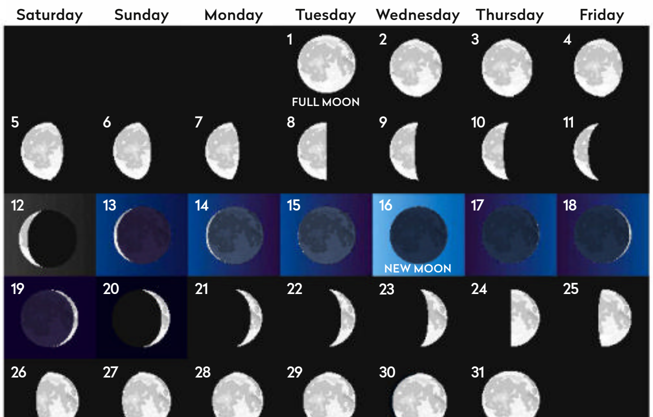
Moonrise in August*

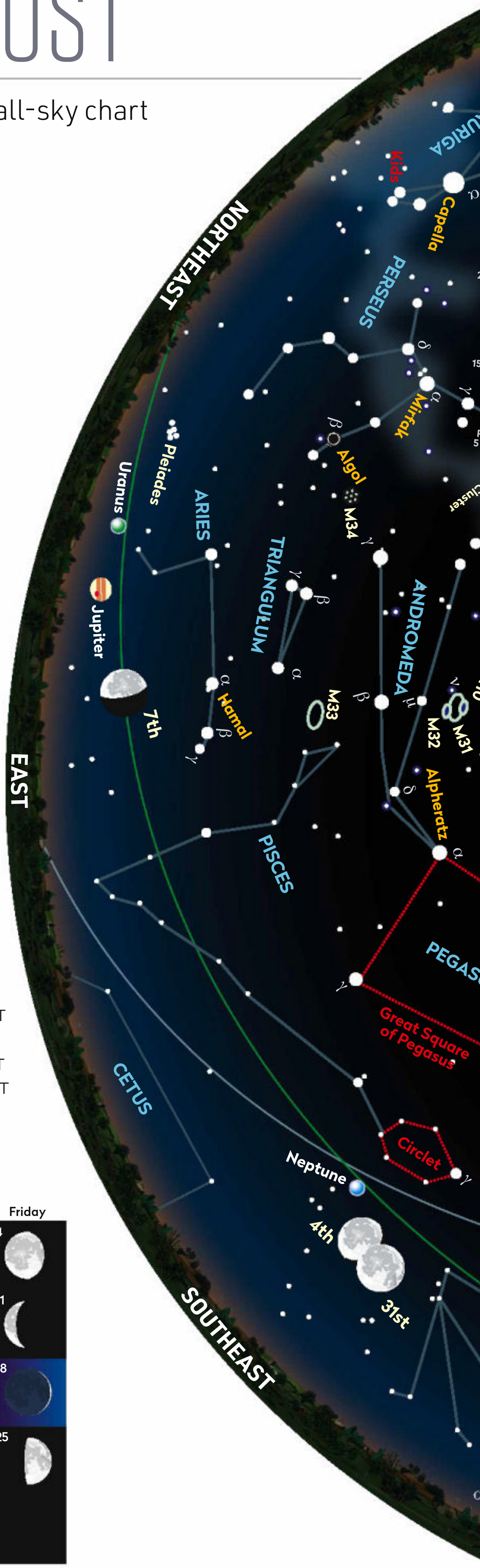
Moonrise times

1 Aug 2023, 21:43 BST	17 Aug 2023, 06:36 BST
5 Aug 2023, 22:41 BST	21 Aug 2023, 11:28 BST
9 Aug 2023, 23:40 BST	25 Aug 2023, 16:54 BST
13 Aug 2023, 01:45 BST	29 Aug 2023, 20:06 BST

*Times correct for the centre of the UK

Lunar phases in August





MORE ONLINE

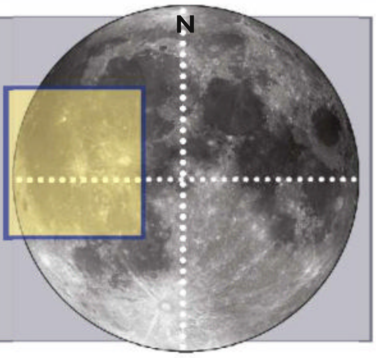
Paul and Pete's night-sky highlights

Southern Hemisphere sky guide

MOONWATCH August's top lunar feature to observe

Copernicus

Type: Crater
Size: Approximately 93km across
Longitude/latitude: 20.1° W, 9.6° N
Age: Up to 1.1 billion years
Best time to see: 2 days after first quarter (25–26 August) or 1 day after last quarter (10 August)
Minimum equipment: 50mm refractor



Copernicus is an impressive 93km crater located just south of the giant **Mare Imbrium** lunar basin. It's a relatively youthful feature with a sharp, highly detailed rim, largely unaffected by the battering that erodes the definition of older craters. It is surrounded by an extensive ray system that extends into and colours much of the surrounding dark lava. To the north, the rays extend well into Mare Imbrium, easily seen as they cross the floor, emanating out of the focal point that is Copernicus.

There are many craters on the Moon surrounded by radiating lines of bright ejecta, the most striking examples being relatively young. This is due to ejecta rays fading over time, so the older examples don't stand out so well. The most prominent ray craters on the Earth-facing side of the Moon are Copernicus, 86km **Tycho** in the south, 31km **Kepler** located to the west of Copernicus and 40km **Aristarchus** to the northwest of Kepler. Of the four, Tycho's rays are the most impressive, being traceable for thousands of kilometres from the point of impact.

The Copernicus–Kepler–Aristarchus trio are in the same general region of the Moon and their rays fill the triangle that they form. A lack of bright, rugged highland areas here leave the rays room to pass over dark, flat lava, which helps them to stand out. When all three craters are visible from just before full Moon through to the last quarter Moon, the criss-crossing rays look like some giant alien communication network.

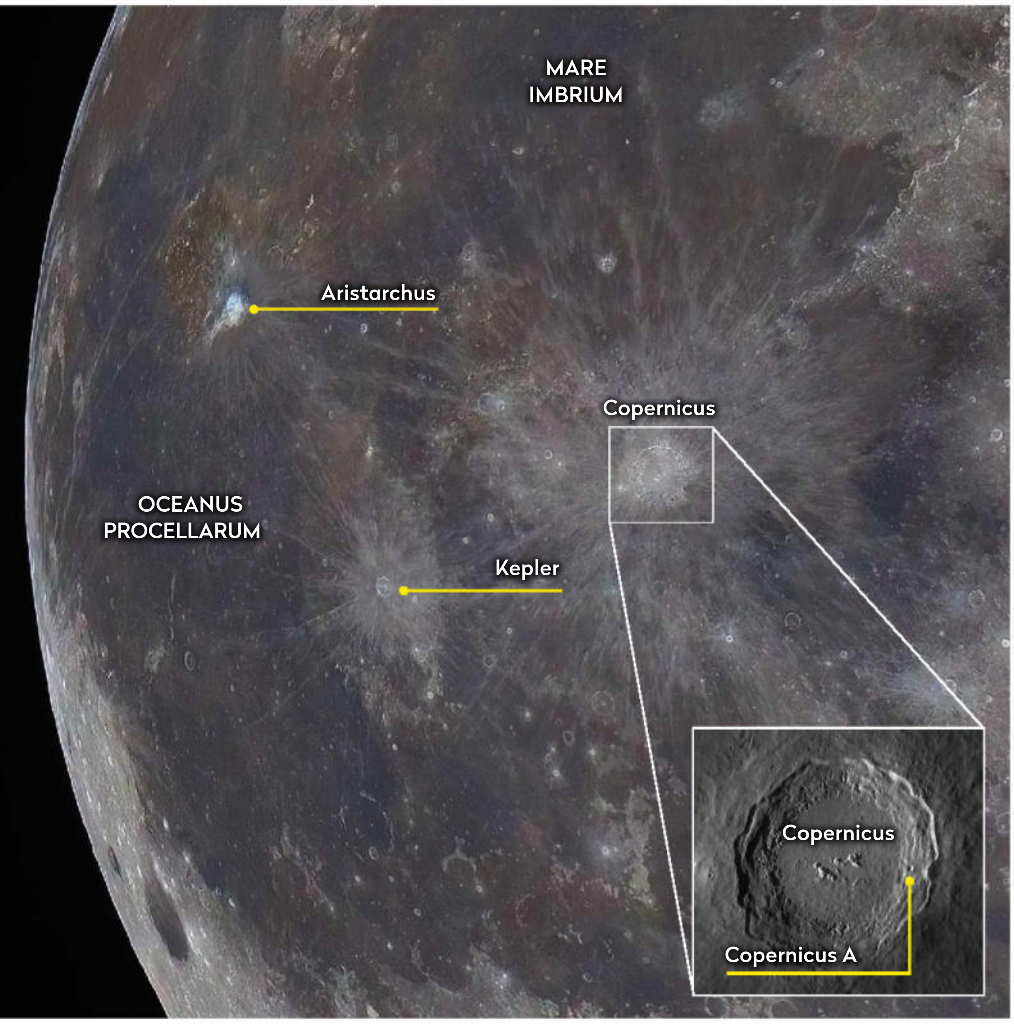
Copernicus is very detailed and, as mentioned earlier, well-presented. Its rim appears circular at first glance, but careful study shows it's polygonal in shape, appearing more hexagonal or even heptagonal than a true circle. Approaching Copernicus from the outside, its outer ramparts rise out of **Oceanus Procellarum** (the Ocean of Storms) gently at first, then accelerating to reach the lofty outer rim.

The rim and its internal terraces are very complex, exhibiting a striking number of twists and turns that vary in appearance as internal shadows wax and wane with the altitude of the Sun as seen from Copernicus. The rim edge towers 3.8km above the crater's floor, but to travel from rim to floor you would have to traverse those exquisitely complex terraces.

The crater's floor appears smooth under direct lighting. However, when the Sun's altitude gets low in Copernicus's sky, it's possible to see that there are many shallow hills rolling across the floor. The coverage is curious in that the northwest floor quadrant is markedly smoother than the rest.

Copernicus has a well-defined central mountain complex located at the crater's centre. These mountains rise to a maximum height of just over a kilometre and are arranged in three main groups: a linear range to the west, a smaller collection in the centre and a more irregular group to the east. The youthful nature of Copernicus means there are no significant craterlets visible on its floor. The only significant crater within the outer rim is 3km **Copernicus A**, which lies within the eastern rim terraces and requires a 200mm or larger instrument to see.

▼ **Surrounded by ejecta rays, Copernicus is unmistakable. With magnification you'll see its striking terraced walls**



PETE LAWRENCE X 3

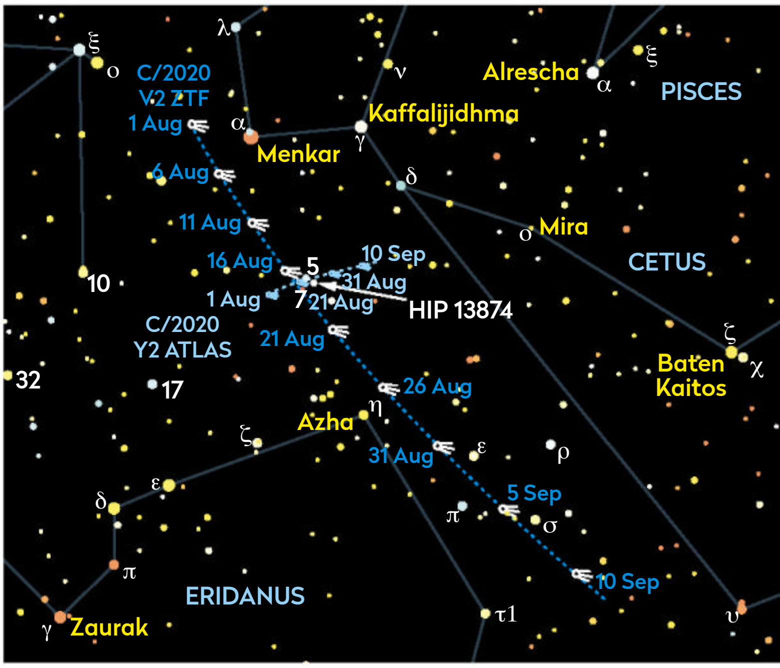
COMETS AND ASTEROIDS

Wait for the Moon to exit the scene to catch comet C/2020 V2 ZTF in Cetus

Comet C/2020 V2 ZTF is a small telescope target, heading south all month. It stays more or less the same brightness throughout August, starting the month at mag. +9.8 and ending it at mag. +9.7. It's an early morning object, starting its monthly track just east of the 'head' of Cetus the Whale, a pattern of stars conveniently located south of bright Jupiter. Look for it 2.3° to the east-northeast of Menkar (Alpha (α) Ceti) on the morning of 1 August. Its path then takes it south, arcing subtly west. The Moon interferes with the view early in August, passing north of the comet at its last quarter phase, on the morning of 8 August.

This isn't too much of a problem though, because the lost viewing time at the start of August is when the comet is very low from the UK. As the Moon moves out of the way mid-month, this region of sky will appear higher before the onset of dawn.

On the morning of 17 August, C/2020 V2 ZTF is located near a triangle of sixth-magnitude stars 6.5° south of Menkar. The triangle consists of 5 and 7 Eridani (mag. +5.5 and +6.1 respectively) together with mag. +5.2 HIP 13874. A long-exposure photograph of this region may well show another comet which is travelling at right angles to the path of C/2020 V2 ZTF. This fainter comet is C/2020 Y2 Atlas and is expected to be around mag. +16.5 at the time.



▲ C/2020 V2 ZTF crosses paths with another comet on 17 August

C/2020 V2 ZTF continues south, veering slightly further to the west as it goes. It runs parallel to the line between Azha (Eta (η) Eridani) and Pi (π) Ceti between 26 August and 3 September.

STAR OF THE MONTH

Althalimain, the tail of Aquila the Eagle

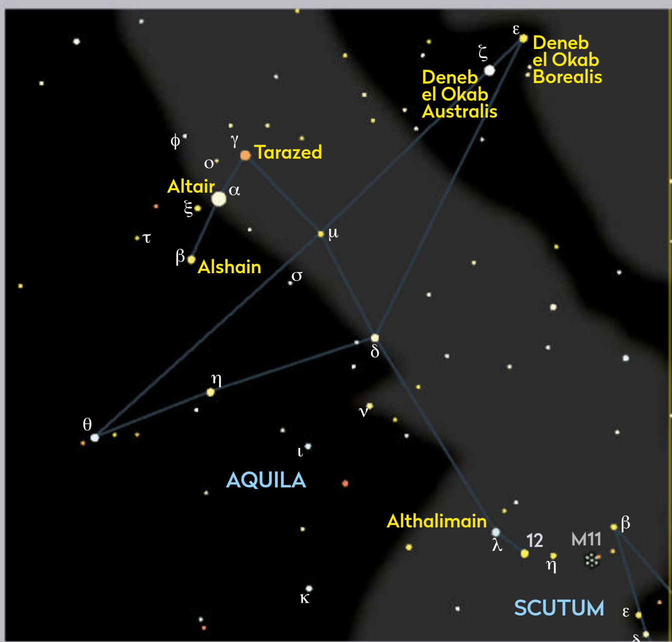
The southern end of Aquila the Eagle, as it approaches Scutum the Shield, is marked by a small curve of stars starting with mag. +3.4 Althalimain (Lambda (λ) Aquilae), then mag. +4.0 12 Aquilae and finally mag. +4.8 Eta (η) Scuti.

Althalimain (or Al Thalimain) is derived from the Arabic 'the two ostriches'. If you're wondering where the other ostrich is, 8.4° to the northwest is mag. +4.3 Iota (ι) Aquilae which is also named Althalimain. Strictly speaking, as Lambda leads Iota across the sky, Lambda Aquilae should be known as Althalimain Prior.

Lambda has a spectral type B9 Vn. 'B9' means it's a hot star of around 11,800 Kelvin which appears blue-white. 'V' means it's a main sequence dwarf and 'n' indicates that its spectrum shows broad absorption lines caused by rapid spinning. Its rotational velocity is around 50 times faster than that of the Sun: 103km/s vs 2km/s. Lambda Aquilae is 125 lightyears distant and around 3.1 times more massive, 1.9 times larger and 55 times more luminous than our Sun.

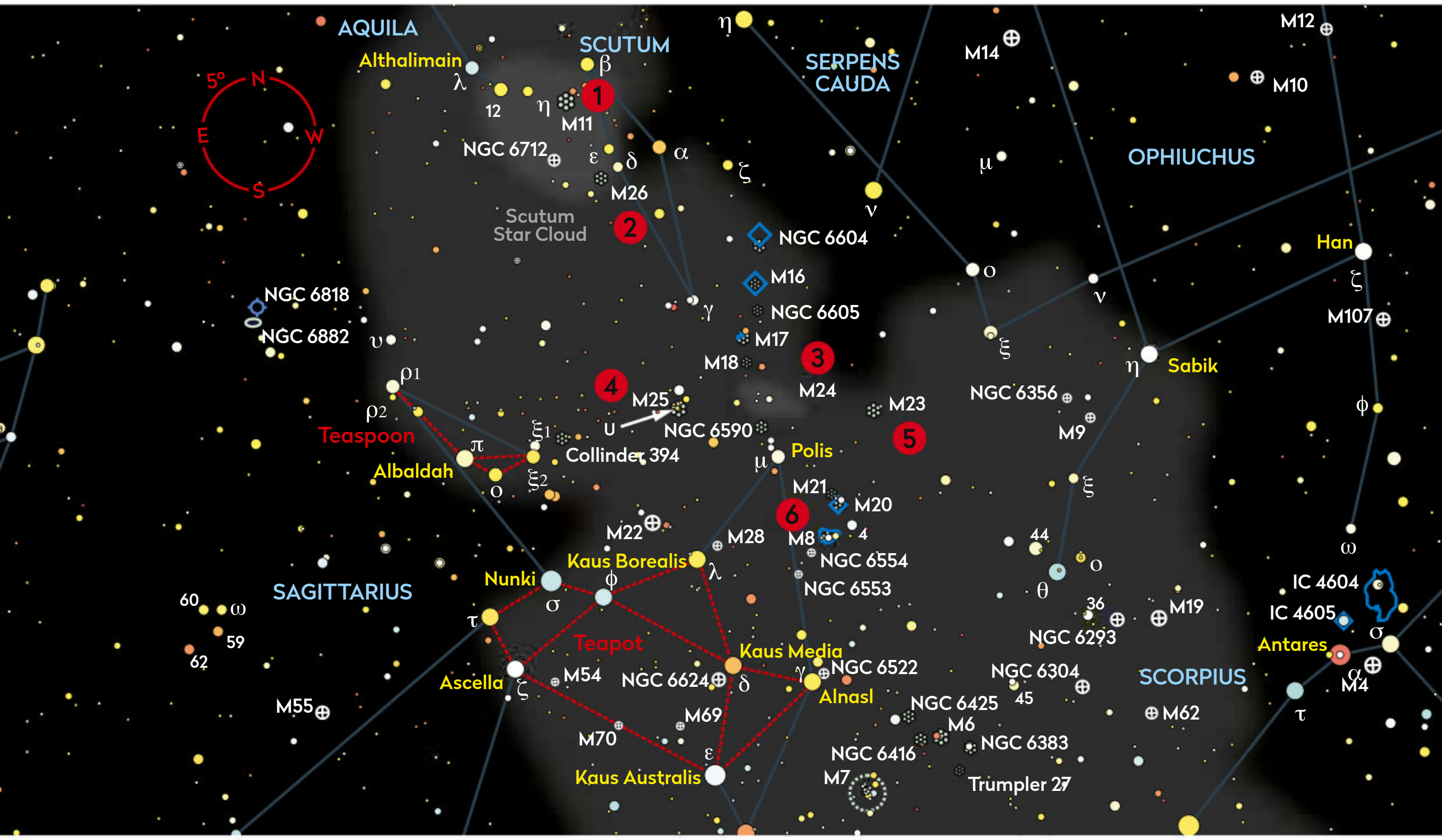
Although electronically dead, the Pioneer 11 probe launched in April 1973 will make its closest approach to the star in 4 million years.

▼ Lambda Aquilae is one of two stars called Althalimain, the other being Iota Aquilae



BINOCULAR TOUR With Steve Tonkin

Set your sights low for six lovely targets in the southern Milky Way



1. M11, the Wild Duck Cluster

10x 50 Our tour of the southern portion of the Milky Way begins with one of the densest open clusters, M11, the Wild Duck Cluster. You'll find it 2° southeast of mag. +4.2 Beta (β) Scuti, spanning about 0.25° of sky. In 10x50 binoculars, the cluster appears as a bright, slightly wedge-shaped glow. Were it not so rich, you may have had trouble identifying it against the Scutum Star Cloud, the densest part of the Milky Way. ☐ **SEEN IT**

2. M26

15x 70 If you put mag. +3.8 Alpha (α) Scuti at the northwest of your field of view, open cluster M26, also known as NGC 6694, will be southeast of centre. Although it is only mag. +8.0, M26 is easy to find. Look for a glowing kite shape which has the unusual feature of being less bright in the middle, due to some intervening interstellar dust, so what you see is an open cluster with a tiny dark nebula in the middle. ☐ **SEEN IT**

PETE LAWRENCE X 2

3. M24, the Sagittarius Star Cloud

10x 50 M24 lies slightly more than half-way from mag. +4.7 Gamma (γ) Scuti to mag. +3.8 Polis (Mu (μ) Sagittarii). It is a bright patch of light that is easily visible to the naked eye and which has even been mistaken for a cloud just above the horizon. It is a remarkably good object in 10x50 binoculars, in which nearly 1,000 stars are resolved in a single field of view! ☐ **SEEN IT**

4. M25 and U Sagittarii

10x 50 If you navigate 4.5° south from Gamma Scuti, you should easily find the bright (mag. +4.6) open cluster M25, showing distinctly against the background Milky Way, with eight or so stars resolved against a grainy background. It's easier to distinguish the cluster from the background Milky Way in small binoculars than in large ones. The brightest star in the cluster is the Cepheid variable, U Sagittarii (which varies from mag. +7.2 to +6.5). ☐ **SEEN IT**

5. M23

15x 70 M23 is just over half-way from mag. +3.5 Xi (ξ) Serpentis to Polis, but may be difficult to distinguish from the rich background of the Milky Way. This bright, oval (15x27 arcminutes) open cluster is lovely in 70mm binoculars, which reveal about a dozen stars in the shape of a lower-case letter alpha (α) against the background glow of another 140 fainter stars. ☐ **SEEN IT**

6. M8, the Lagoon Nebula

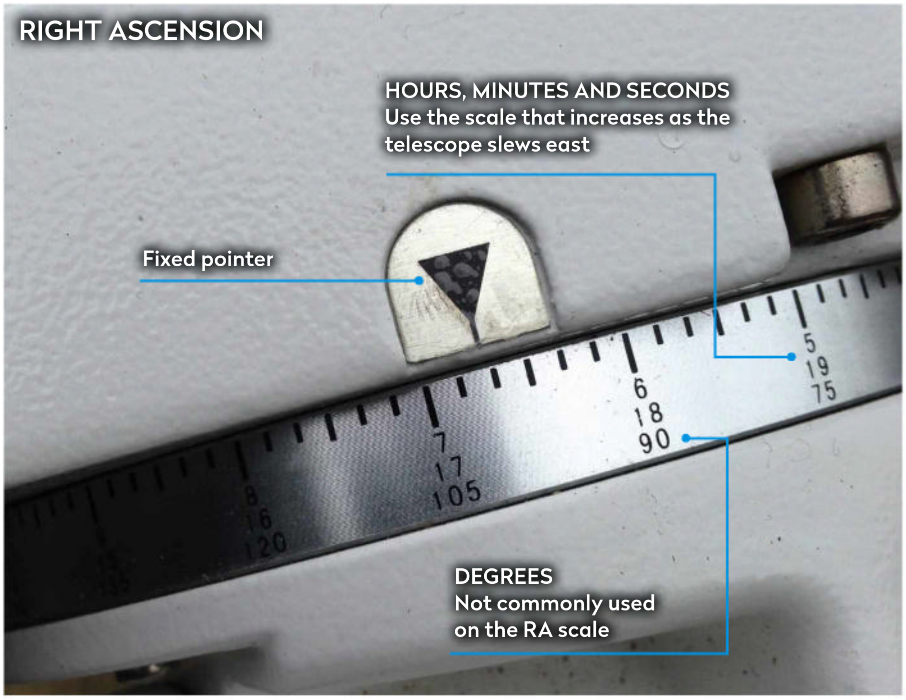
10x 50 Look for M8, the Lagoon Nebula, 6° west-northwest of mag. +3.0 Kaus Borealis (Lambda (λ) Sagittarii). It is visible to the naked eye if it's high in a reasonably dark and transparent sky. With 10x50s you'll resolve more than half a dozen stars and reveal some of the surrounding nebulosity (NGC 6523) they illuminate, as well as the denser cluster of stars to the east of the main nebulosity. ☐ **SEEN IT**

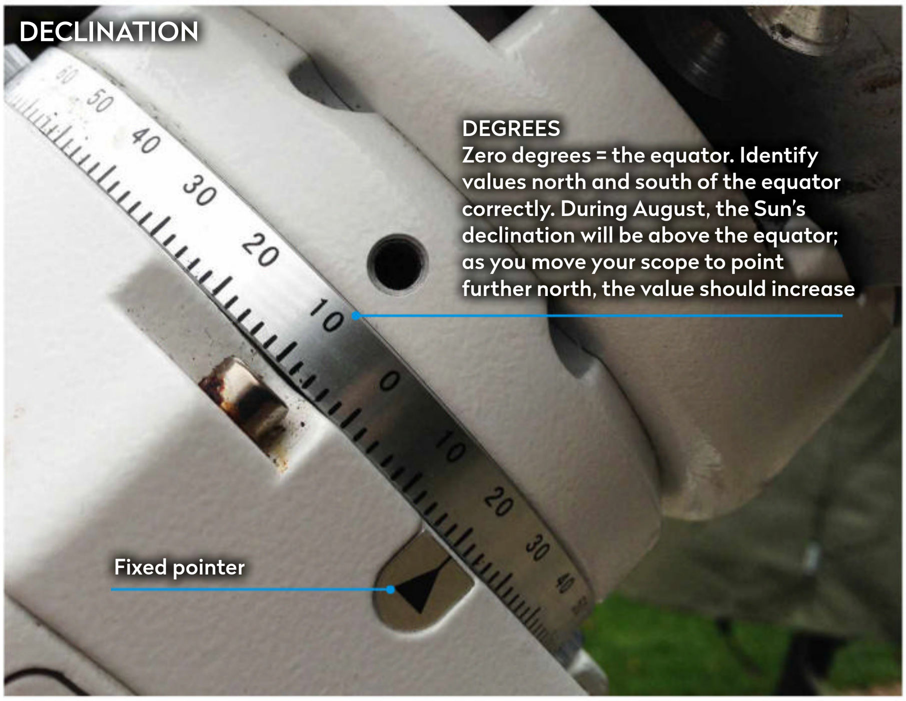
☑ Tick the box when you've seen each one

THE SKY GUIDE CHALLENGE

CAUTION
Never observe or image the Sun with the naked eye or any unfiltered optical instrument

Use setting circles to find Venus's delicate crescent at inferior conjunction





◀ **Setting circles aren't complicated to use, but you need to pay attention to the values to make sure you're using the correct scale**

Venus reaches inferior conjunction on 13 August (see **page 47**), when at 12:15 BST (11:15 UT) it will pass 7.7° from the centre of the Sun. With care you can make a record of this, which is this month's challenge.

First and foremost, pointing a telescope close to the Sun is dangerous and extreme care needs to be exercised. If you're not sure what you're doing, we strongly recommend that you don't attempt this challenge.

The safest setup to use would be a small to mid-sized refractor along with a high-frame-rate camera fitted with a red or infrared pass filter. Don't attempt to see this visually. Any finderscopes will also need to be capped or removed. You'll need a full-aperture white-light solar filter and for the purposes of this challenge we assume that you'll use a driven, polar-aligned equatorial mount which has setting circles.

Set the telescope up and turn on the mount drive. A wide camera field is recommended, ideally one that sees the entire Sun in one go. Remove or cap finders. Check that the solar safety filter isn't ripped or lets light through – discard it and use a new one if so. Once checked, fit it and point the telescope at the Sun. Focus as accurately as possible on the Sun's disc. Once focused, centre the Sun in your field of view using a crosshair overlay, if your camera's control program has this option. Otherwise, use your best judgment. Set the mount's slew speed slow enough that it takes several seconds for the Sun to cross the field of view.

Use a planetarium app (for example Cartes du Ciel, **www.ap-i.net/skychart/en/start**) and work out the Sun's right ascension (RA) and declination (dec.) for the time you're observing. Unlock the dec. setting circle scale and rotate it so it reads the Sun's dec., then lock it again. Make sure you're using the part of the scale that increases in value if you move the telescope north.

Similarly, set the setting circles to the Sun's current RA value. Use the scale that increases if you move the scope east. Once set, look up the RA and dec. coordinates of Venus. Carefully move the scope so the setting circle pointers indicate the values for Venus. As a safety check, ensure you're not pointing at the Sun, then carefully remove the solar filter. Double-check that sunlight isn't passing too far down the tube – if it is, re-cover the scope and abort the attempt.

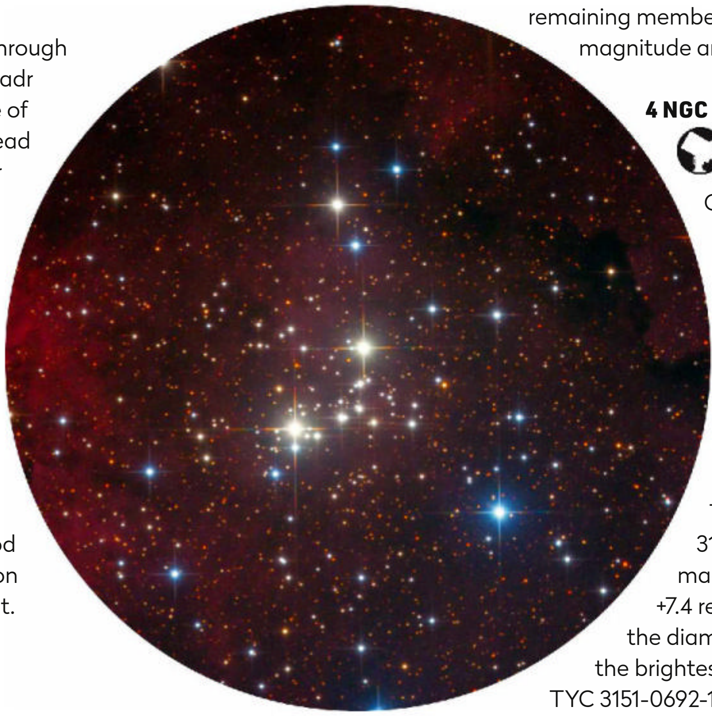
Adjust the camera settings to boost the sky brightness and look for the fine, 0.9%-lit Venusian crescent. If it's not visible, you can apply short slew bursts to emulate a spiral pattern in the sky. Be careful though – you don't want to slew too far so that the Sun appears! If you simply can't find the planet, replace the solar filter and start over.

DEEP-SKY TOUR

Hop from Sadr to hunt our six delightful targets in the middle of Cygnus the Swan

1 NGC 6910

Anchoring our hunt through Cygnus is mag. +2.2 Sadr (Gamma (γ) Cygni) at the centre of the Northern Cross asterism. Head 0.5° north-northeast of this star and you'll arrive at our first target, open cluster NGC 6910. This is a relatively small cluster, 10 arcminutes across. Its two brightest stars, at mag. +7.3 and +7.0, are easy yellow suns for smaller scopes. They form the 'feet' of a horse-shaped asterism, the Rocking Horse Cluster, the body, legs and tail formed from the fainter stars and a good imagination. Use a magnification around 200x if conditions permit. ☐ **SEEN IT**



▲ **Our tour kicks off with NGC 6910, an open cluster that, like others in the list, you'll need to pick out against the galactic plane. Its two distinctive bright, yellow stars should help**

2 M29

Our next object, the open cluster M29, lies 1.75° south and a fraction east of Sadr. In theory it shouldn't be too hard to find, but the rich background star fields of the Milky Way and its small apparent diameter of around 7 arcminutes can trip you up. The best technique is to use a low power and identify what looks like a little nebulous patch, then up the magnification. It has an obvious geometric appearance, an almost square core with a handle, slightly reminiscent of a lacklustre Pleiades. This square pattern has earned it its less than glamourous nickname, the Cooling Tower Cluster. ☐ **SEEN IT**

3 IC 4996

Starting from M29, head 1.75° to the southwest to locate another open cluster, IC 4996. This sits 0.5° south of 34 Cygni (also known as P Cygni), a hypergiant star and the brightest in the Cygnus OB1 association of young, massive stars. The cluster, together with M29 and Berkeley 86, all belong to this association. Dust between us and these clusters dims them, and in the case of IC 4996, the dimming is between 1.3 and 2.4 magnitudes. IC 4996 is of similar brightness to M29 and slightly smaller at 6 arcseconds. Medium to high powers are required to see it properly, its three core stars forming a tight pattern. They shine at mag. +8.8, +8.0 and +9.7, the remaining members being closer to 11th magnitude and fainter. ☐ **SEEN IT**

4 NGC 6888

Starting at Sadr, head southwest towards Eta (η) Cygni. NGC 6888, the Crescent Nebula, sits one-third of the way along this line. It can be seen with a 150mm scope, but it's a hard challenge. It better suits large-aperture, widefield instruments. The key is to locate the diamond asterism formed from TYC 3151-2837-1, TYC 3151-2843-1, TYC 3151-0692-1 and TYC 3151-1765-1 which have magnitudes of +8.0, +7.2, +8.2 and +7.4 respectively. The longest axis of the diamond is 15 arcminutes. Look for the brightest arc of nebulosity between TYC 3151-0692-1 and TYC 3151-2843-1 (a UHC or OIII filter really helps), then trace the crescent's fainter glow as it curves to the southwest. ☐ **SEEN IT**

5 NGC 6883

Lying 2.5° south of NGC 6888 is NGC 6883, another cluster that's challenging to pick out against the rich background star fields. With smaller instruments, it isn't obvious but it can be seen. A 250mm scope shows a loose collection of about a dozen stars concentrated in a region 4 arcminutes across. The full size of the cluster is at least 15 arcminutes across. Increased aperture reveals more members, a 300mm scope almost trebling the count. The variable carbon star RY Cygni sits immediately northwest of the cluster and exhibits brightness variations between mag. +8.5 and +10.3. Look out for the tight double at the centre of the cluster, formed from a mag. +9.4 and +9.7 pair separated by 16 arcseconds. ☐ **SEEN IT**

6 NGC 6871

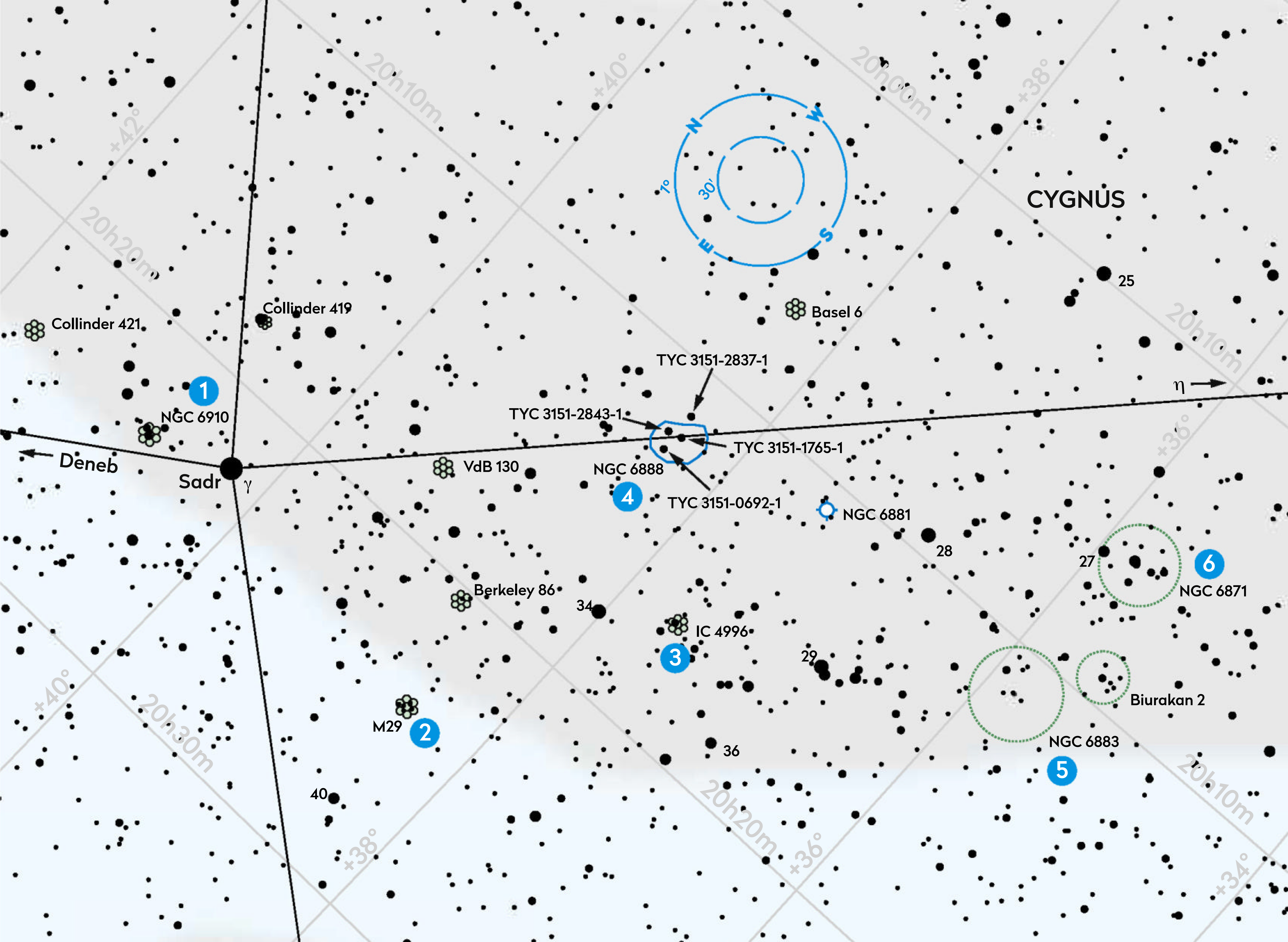
Our final target sits 1.1° west of NGC 6883 and is also affected by the profusion of background stars. NGC 6871 is immediately south of distinctively orange mag. +5.4 27 Cygni. In a small scope it looks like a trail of stars dangling south of this star. A low power with a larger aperture shows an attractive view formed by the brighter south-trailing stars. Up the power and you'll see a number of close pairs here. With a 300mm instrument, the star count starts to climb to 70+ members, the cluster's appearance aided by the presence of darker regions to the east and west of it. This is a young cluster, estimated to be 9.1 million years old. ☐ **SEEN IT**

BERNHARD HUBL/CCDGUIDE.COM, CHART BY PETE LAWRENCE

This Deep-Sky Tour has been automated
ASCOM-enabled Go-To mounts can now take you to this month's targets at the touch of a button, with our Deep-Sky Tour file for the EQTOUR app. Find it online.

More **ONLINE**

Print out this chart and take an automated Go-To tour. See page 5 for instructions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NGC 6881
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NGC 6871
Berkeley 86
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Biurakan 2
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AT A GLANCE How the Sky Guide events will appear in August

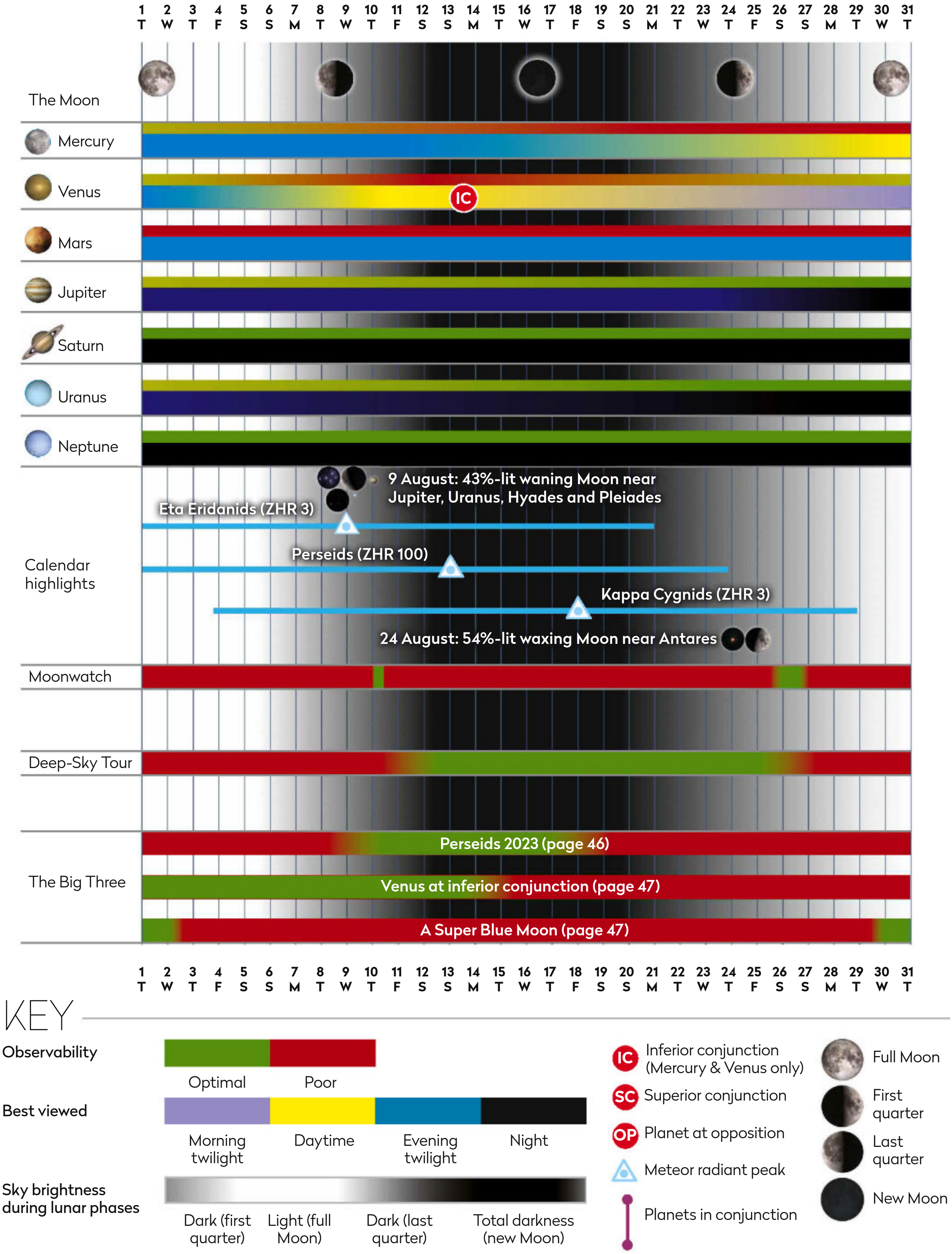


CHART BY PETE LAWRENCE

10 *locations to make you* fall in love with the Moon again

Rekindle your passion for the Moon with **Stuart Atkinson's** pick of the best lesser-known lunar locations you'll love

PETE LAWRENCE, GETTY

Every amateur astronomer starts off loving the Moon. They eagerly set up their telescopes in their garden, squint into the eyepiece and check what they can see against charts in books or magazines, looking for the 'celebrity' lunar features they've heard and read so much about. They whisper in the darkness as they make one discovery after another. "Ah… so that's Copernicus!" "That must be Tycho!" "Wow, they must be the Apennine Mountains." "Is that… yes, I think it is… the Sea of Tranquility!"

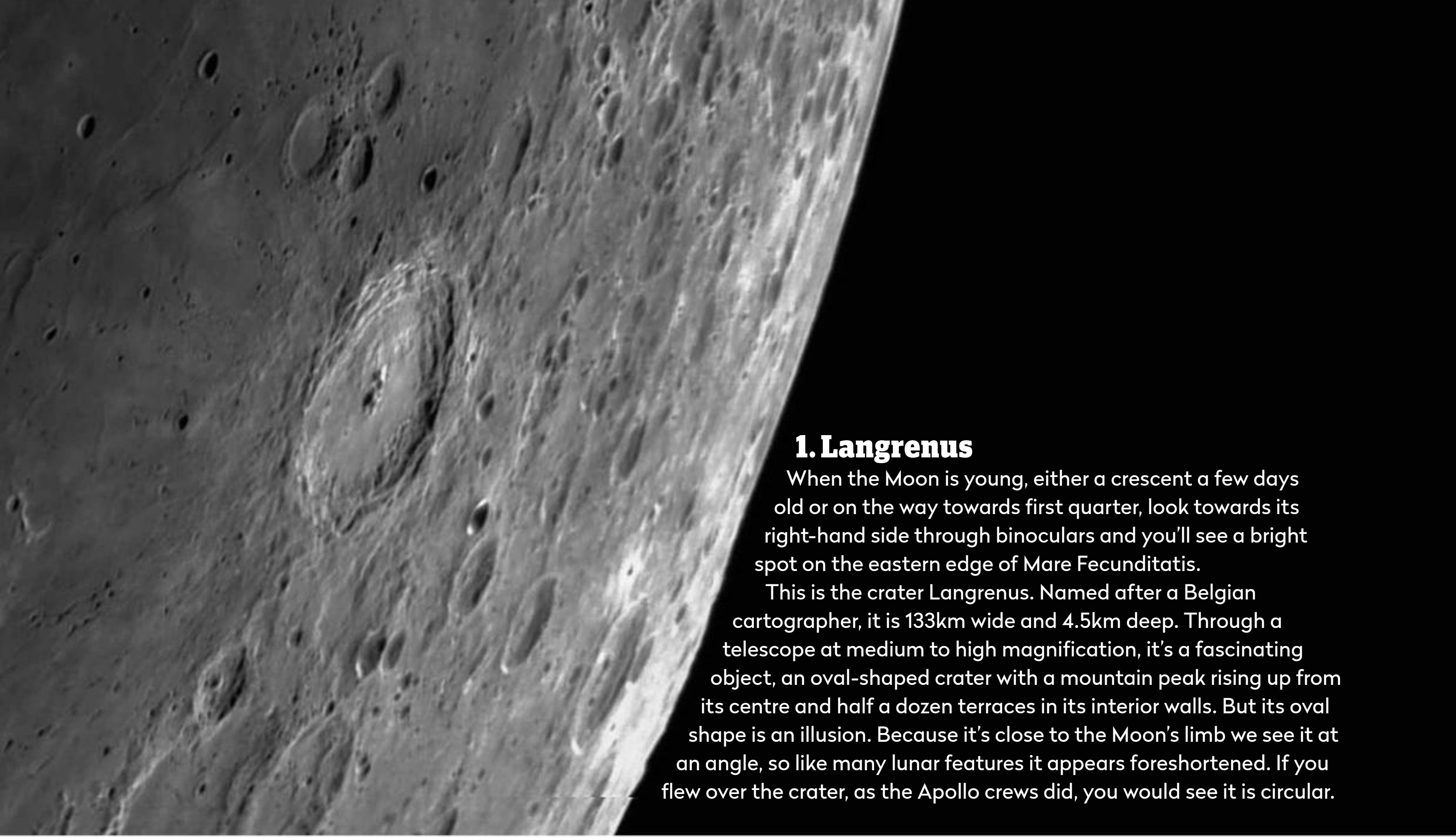
But after a while, the love affair between many new amateur astronomers and the Moon cools. They've seen all the 'good stuff' – the major craters, the most obvious mountain ranges, the ripples on the floors of the seas, and so on – and the Moon has begun to look, and feel, a bit 'samey'. Frustrated with the inhibiting lunar glare, the astronomer begins to actually resent the Moon they had previously loved so much. They turn their back on it and avoid it as much as possible, only going out to observe the night sky when they know the Moon isn't going to be there.

But fear not. We're going to help those of you who have fallen out of love with the Moon to fall in love with it all over again by showing you 10 off-the-beaten-track lunar features you've perhaps never seen before, and nudging you back to a couple of better-known ones that deserve another look. ►

Stuart Atkinson is a lifelong amateur astronomer and author of 11 books on astronomy

◄ Our 10 best sites include jaw-dropping mountains, curious walls, usually-hidden maria and downright weird craters

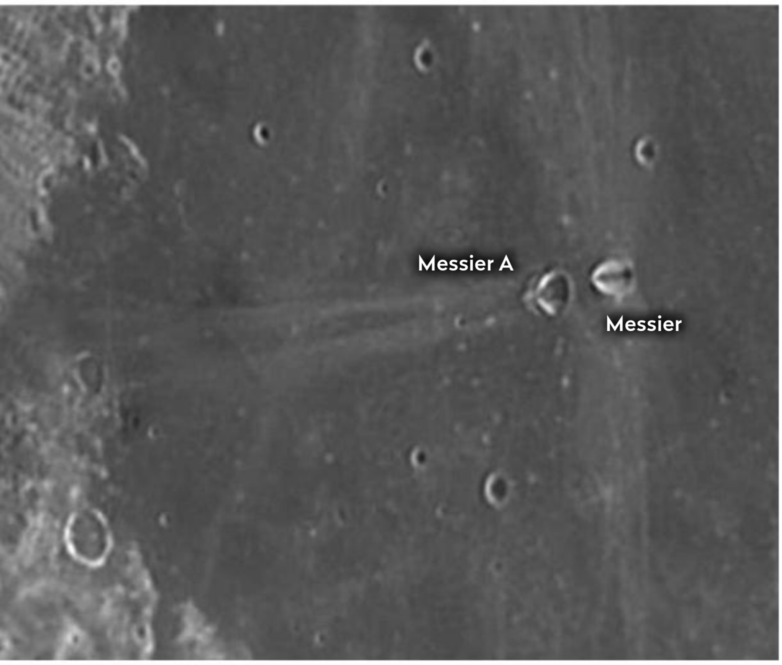
Get ready to see the Moon in a whole new light, from unsung beauty spots you won't know to more familiar places you'll be delighted to rediscover



1. Langrenus

When the Moon is young, either a crescent a few days old or on the way towards first quarter, look towards its right-hand side through binoculars and you'll see a bright spot on the eastern edge of Mare Fecunditatis.

This is the crater Langrenus. Named after a Belgian cartographer, it is 133km wide and 4.5km deep. Through a telescope at medium to high magnification, it's a fascinating object, an oval-shaped crater with a mountain peak rising up from its centre and half a dozen terraces in its interior walls. But its oval shape is an illusion. Because it's close to the Moon's limb we see it at an angle, so like many lunar features it appears foreshortened. If you flew over the crater, as the Apollo crews did, you would see it is circular.



▲ 2. Messier and Messier A

Slowly swing your telescope away from Langrenus, heading towards the northwestern shore of Mare Fecunditatis and just beneath the crater Tarantius you'll come across a pair of small craters, side by side. These are Messier and Messier A, named after the famous deep-sky object cataloguer Charles Messier.

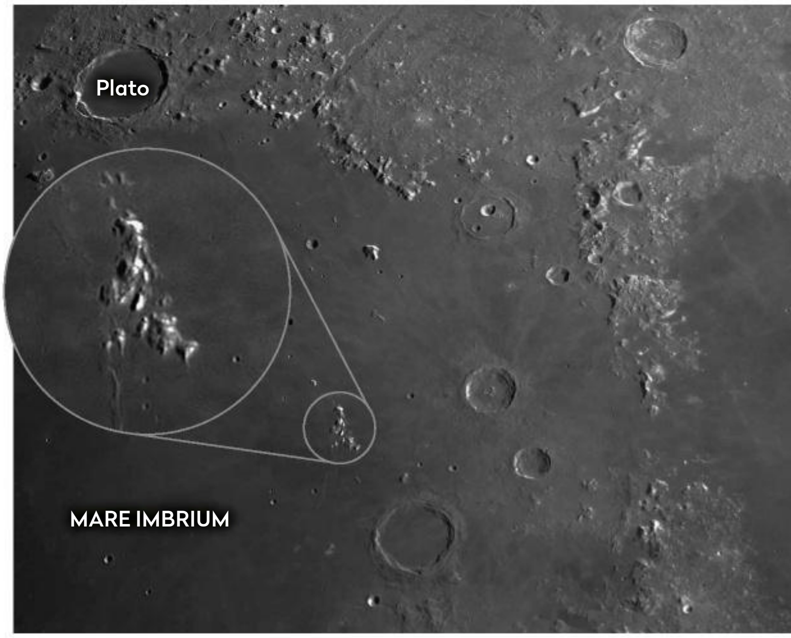
The larger of the two, Messier, is an unremarkable little pit 14km wide, but Messier A is one of the most intriguing craters on the Moon, because a pair of bright rays streak away from its western side like a miniature comet tail or pennant. These rays are best seen when the Moon is full or close to full, and illuminated from overhead by the Sun. Just like the longer, more dramatic-looking rays that surround much larger, 'celebrity' craters like Copernicus and Plato, they are made of dusty and rocky debris that sprayed across the Moon when the crater was formed.

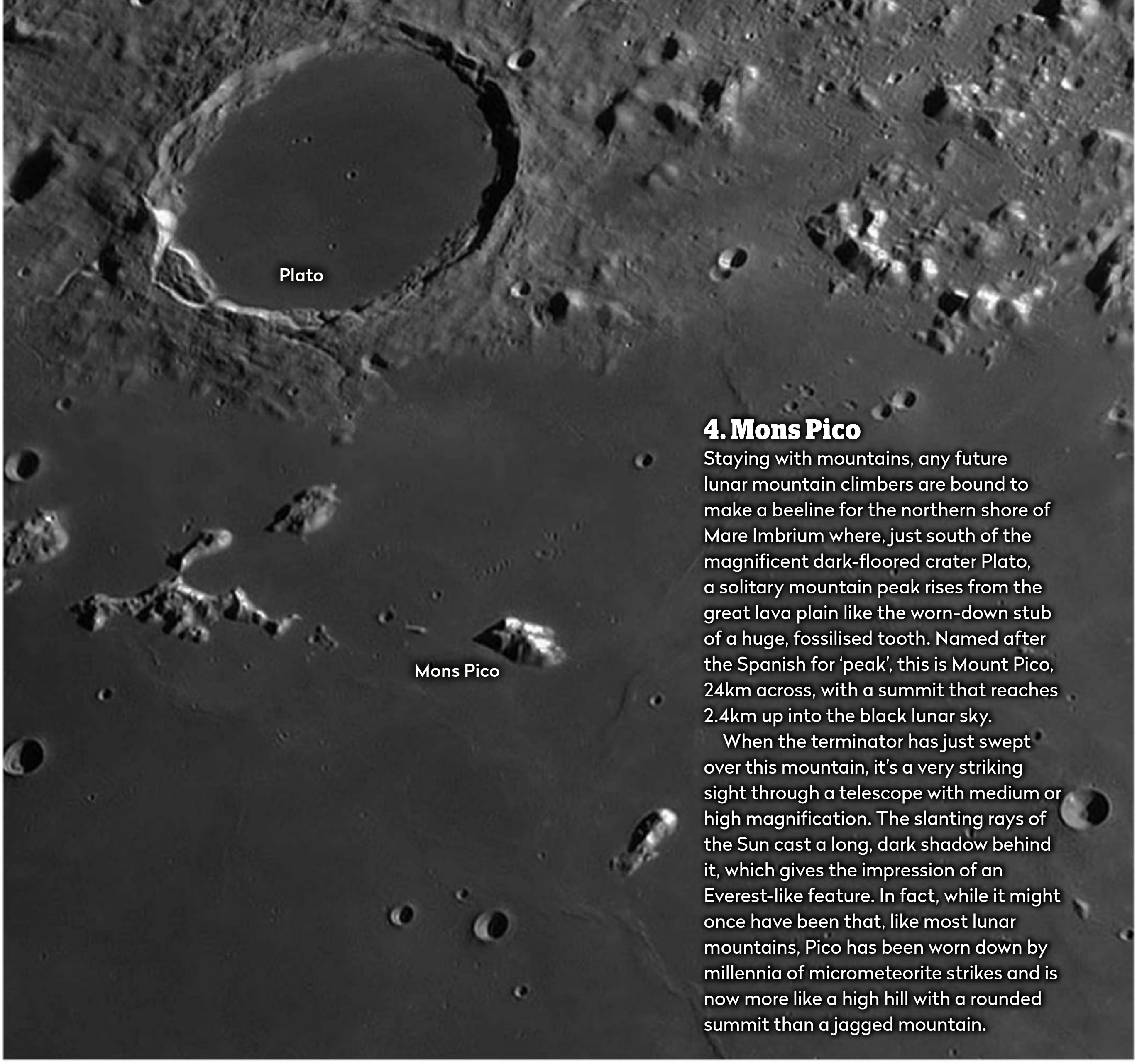
ALL PICTURES: PETE LAWRENCE

▼ 3. Montes Spitzbergen

There are some seriously impressive mountain ranges on the Moon, with peaks so jagged and high that they are easily visible through telescopes or even binoculars in some cases, and no doubt brave/crazy climbers will set their sights on conquering them in the distant future. But scattered across the lunar surface are more isolated peaks too.

If you look towards the eastern shore of Mare Imbrium, just above the large crater Archimedes, you'll see the Spitzbergen Mountains, a lonely, 79km-wide mountain range that looks like an arrowhead pointing west. These peaks are all that remain of an ancient crater that was covered over with lava billions of years ago, when Imbrium was formed. They are best seen under high magnification when the Moon is just past first quarter, because that's when they are closest to the terminator – the line between day and night on the lunar surface – and cast stark shadows across the lava plain from which they rear up.





4. Mons Pico

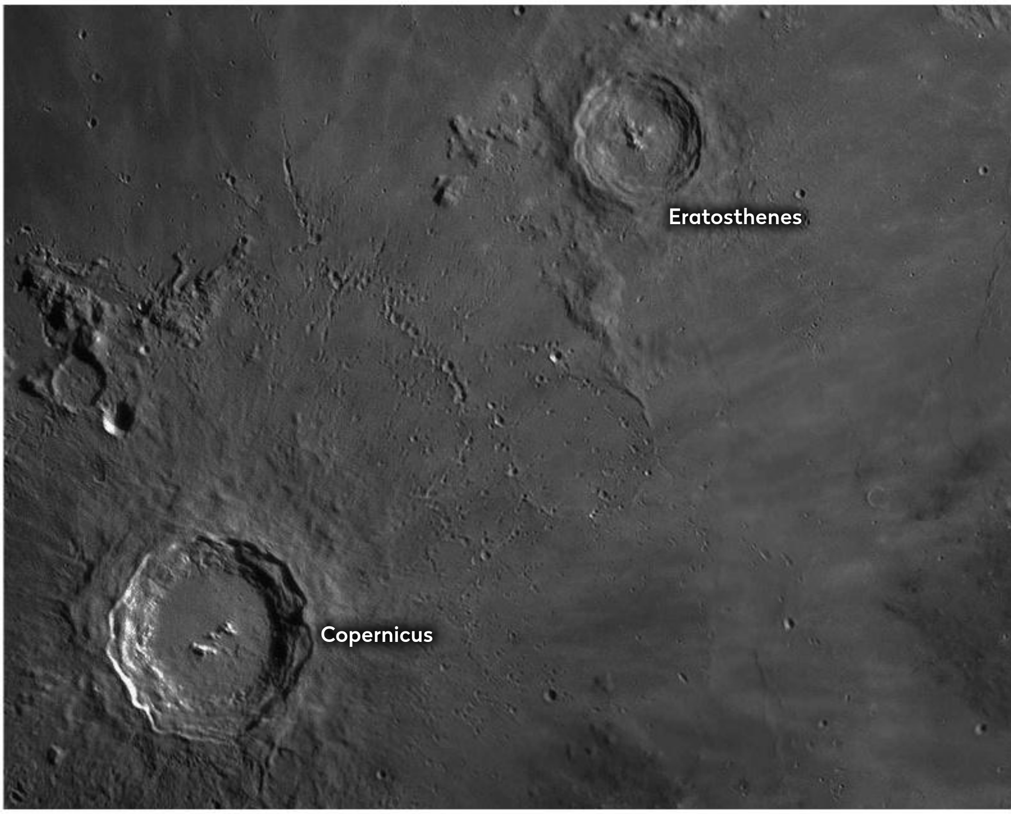
Staying with mountains, any future lunar mountain climbers are bound to make a beeline for the northern shore of Mare Imbrium where, just south of the magnificent dark-floored crater Plato, a solitary mountain peak rises from the great lava plain like the worn-down stub of a huge, fossilised tooth. Named after the Spanish for 'peak', this is Mount Pico, 24km across, with a summit that reaches 2.4km up into the black lunar sky.

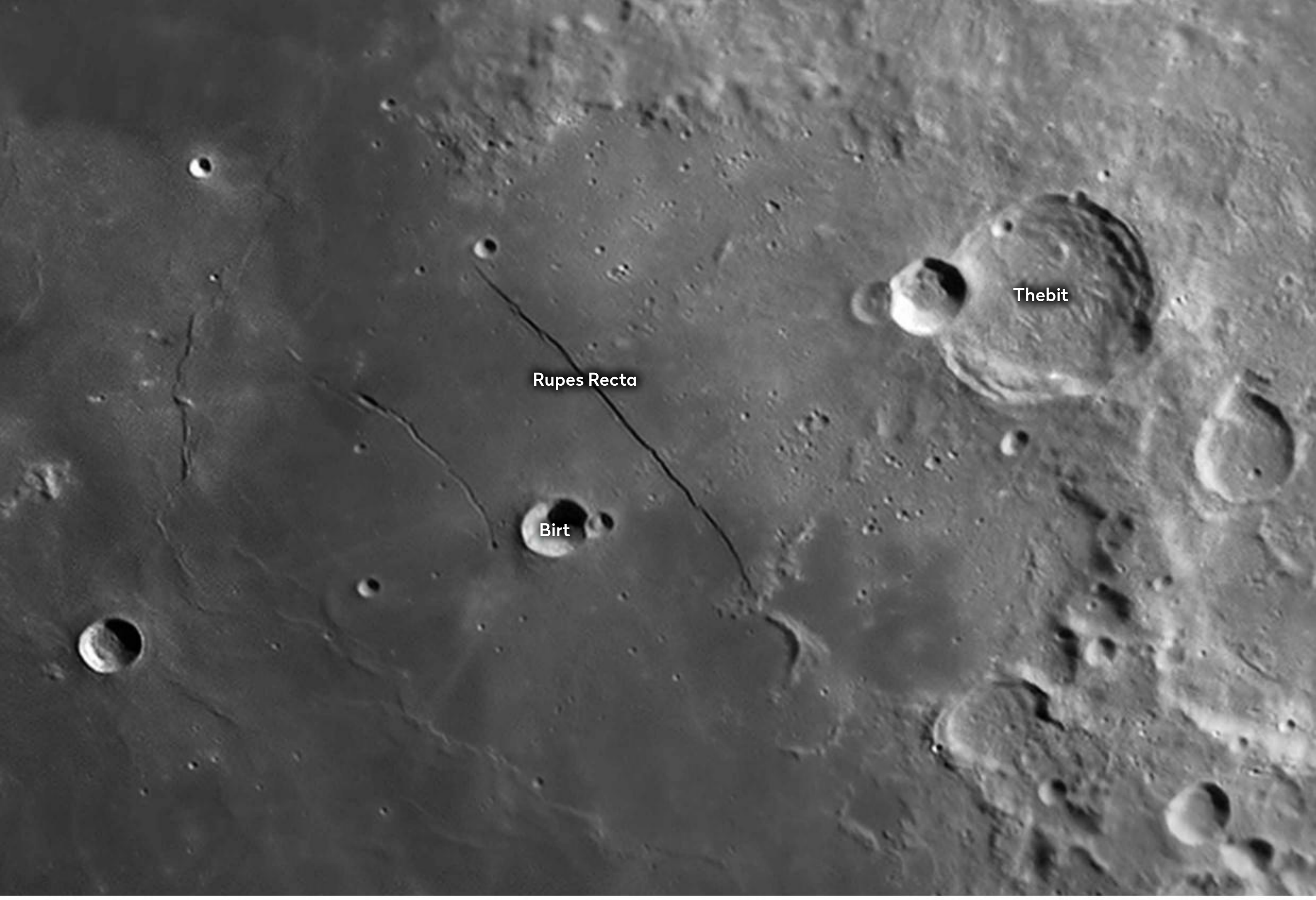
When the terminator has just swept over this mountain, it's a very striking sight through a telescope with medium or high magnification. The slanting rays of the Sun cast a long, dark shadow behind it, which gives the impression of an Everest-like feature. In fact, while it might once have been that, like most lunar mountains, Pico has been worn down by millennia of micrometeorite strikes and is now more like a high hill with a rounded summit than a jagged mountain.

5. Eratosthenes ▶

Our next target may be one of the Moon's most striking craters, but like many astronomical objects it's often overlooked, overshadowed by bigger and more spectacular-looking neighbours. With the gaping, ray-splashed pit of Copernicus to its west and the curve of the stegosaur spine Apennine Mountains stretching away to the north and east, 60km-wide Eratosthenes is easily visible in binoculars and a stunning sight through a telescope.

At high magnification, you can imagine you're looking down at it from an orbiting Artemis capsule. In moments of steady seeing, you can pick out a multitude of features within: its wigwam-shaped central peak, smaller craters spattered across a rugged rumpled floor and its terraced walls, marked with multiple slumps and landslides. The best time to see Eratosthenes is when it's near the terminator, when it stares out from the Moon like an empty eye socket. At full Moon it becomes rather lost beneath Copernicus's rays. ▶





▲ 6. The Straight Wall

You may think the most fascinating features on the Moon are impossible to miss, but some take a lot of tracking down. Rupes Recta, better known to generations of lunar observers as 'The Straight Wall', is only visible clearly when the terminator is sweeping towards it or has just rolled over it. Then you'll see what looks like a short, straight line just to the east of the crater Birt.

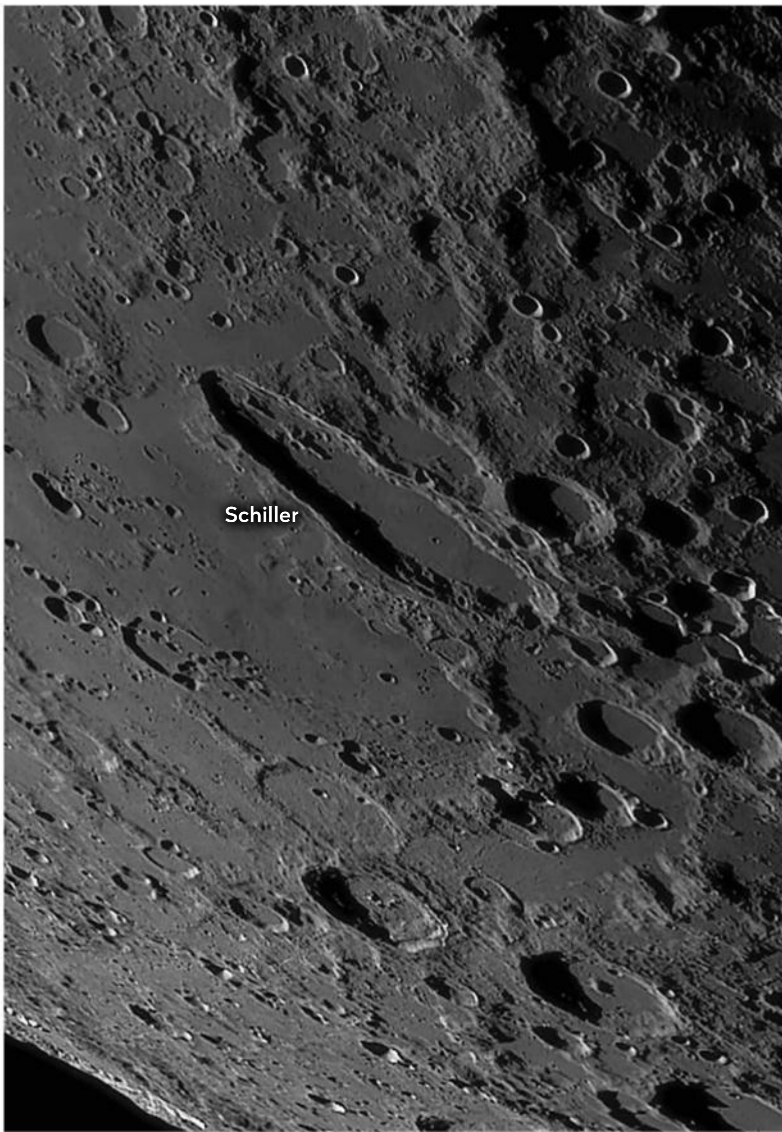
When the Sun is to its west, the Straight Wall is a bright scratch on the dark surface; when the Sun is low in its eastern sky, the Wall looks like a dark line drawn in charcoal on the Moon's grey face. It was once believed this 120km-long and 0.3km-high feature was a towering cliff face, but today we know it's a fault in the Moon's crust, a slope with a gradient of just 10 degrees: too steep for future settlers to tow a caravan up safely, but easy for them to hike up, even in spacesuits.

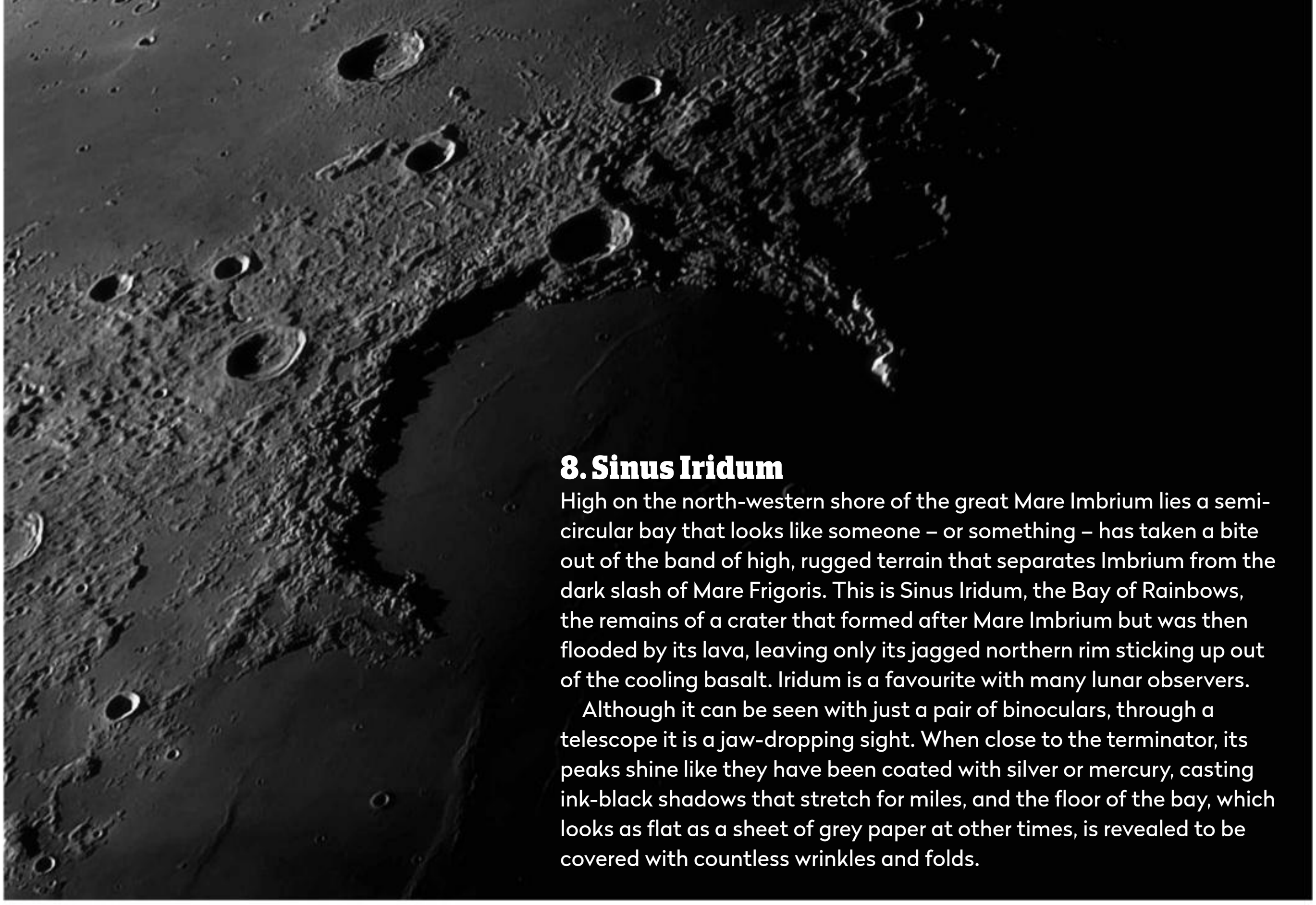
7. Schiller ▶

A sweep across the face of the Moon with a telescope shows that the vast majority of impact craters are round in shape. But here and there you will come across something that looks different – or just plain weird. Schiller definitely fits that description. You'll find it down near the bottom of the lunar disc, not far from the famous crater Tycho and very close to the southern limb.

At 179km long, Schiller is an elongated scar left behind when several objects hit the Moon at a low angle at the same time, ploughing out a long gash in the surface. A telescope shows it is fatter at one end than the other, like a bowling pin, and a crest or ridge runs down the centre of the thinner section. The best time to see Schiller is when the apparent wobble of the Moon – known as 'libration' – swings it towards us, and when the terminator is a couple of days away from it.

ALL PICTURES: PETE LAWRENCE

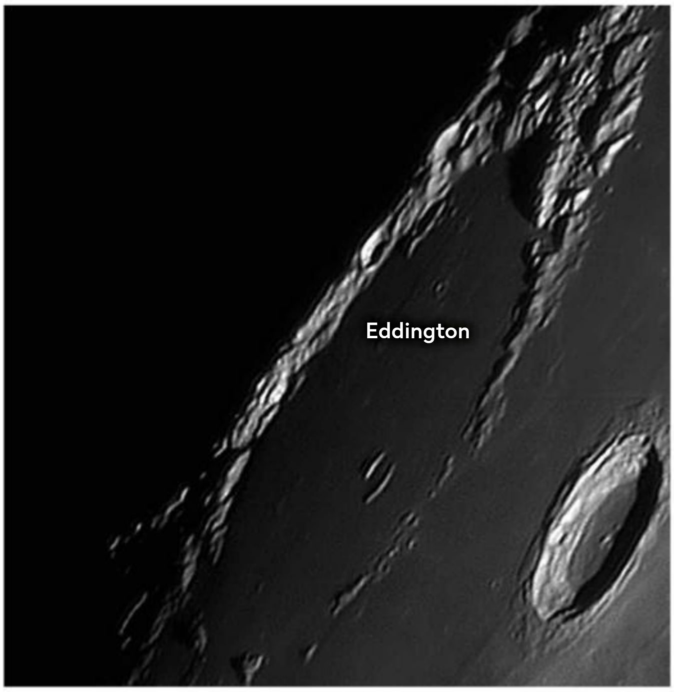




8. Sinus Iridum

High on the north-western shore of the great Mare Imbrium lies a semi-circular bay that looks like someone – or something – has taken a bite out of the band of high, rugged terrain that separates Imbrium from the dark slash of Mare Frigoris. This is Sinus Iridum, the Bay of Rainbows, the remains of a crater that formed after Mare Imbrium but was then flooded by its lava, leaving only its jagged northern rim sticking up out of the cooling basalt. Iridum is a favourite with many lunar observers.

Although it can be seen with just a pair of binoculars, through a telescope it is a jaw-dropping sight. When close to the terminator, its peaks shine like they have been coated with silver or mercury, casting ink-black shadows that stretch for miles, and the floor of the bay, which looks as flat as a sheet of grey paper at other times, is revealed to be covered with countless wrinkles and folds.



▲ 9. Eddington

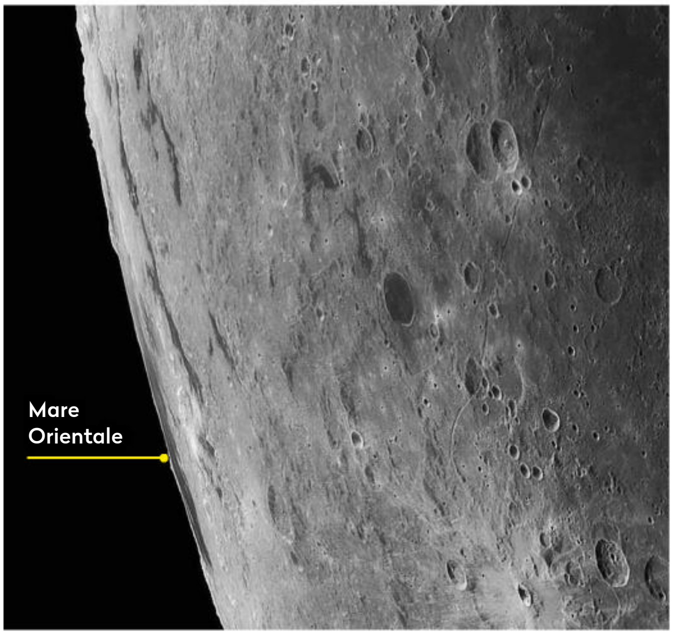
Close to the western limb of the Moon, over to the left of the bright crater Aristarchus, lies Eddington crater – or rather, what's left of it. Once this 134km-wide crater was a complete feature, its rim a ring of jagged rock scratching the starry lunar sky. But when a tsunami of lava swilled into it from the south, the crater was overwhelmed and its rim was partly covered.

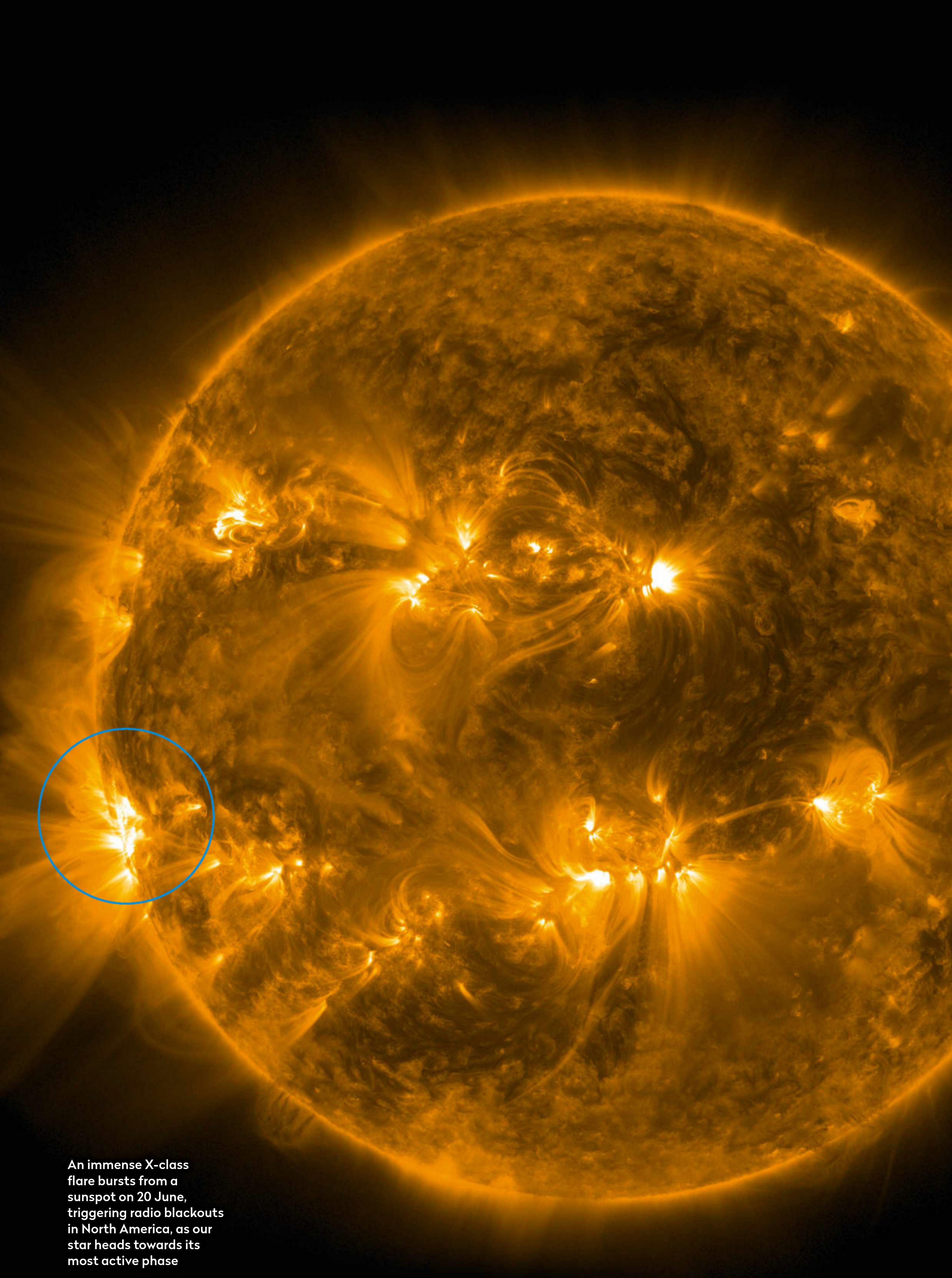
All we see today is a semi-circular bay on the most distant shore of Oceanus Procellarum, like a budget version of nearby Sinus Iridum. This crater remnant is interesting to look at through a telescope because of some subtle, challenging features on its floor, including a very small 'ghost' crater and a shallow rille. It was named after British astronomer, writer and broadcaster Sir Arthur Eddington.

▼ 10. Mare Orientale

We are lucky to have the Moon in our sky. However, we are cheated out of a quite stunning sight, because its most impressive feature is hidden from our direct view, just around the western limb. Mare Orientale is a dark mare surrounded by three concentric rings of mountains, which are more than 900km across and give it a bullseye appearance seen from above.

Unfortunately we can only get a good glimpse at Mare Orientale temporarily as a result of libration, the Moon's apparent wobble over time as seen from Earth. All we can ever see of Mare Orientale, even when libration briefly swings it into better view, is a dark, elongated smudge right on the limb, with hints of brighter ridges around it. If Orientale had been formed on our side of the Moon, it would dominate its face, and during a total lunar eclipse would transform the Moon into a blood-red eye, staring down at us from above.





An immense X-class flare bursts from a sunspot on 20 June, triggering radio blackouts in North America, as our star heads towards its most active phase

The mystery of SOLAR MAXIMUM

The Sun has been increasingly active over the last few years, far more so than astronomers predicted. Ezzy Pearson investigates

Things have been hotting up on the Sun over the last few years. In December 2019, its surface was a very quiet place, a time known as the solar minimum. In the years since, it has been gradually waking up, with sunspots and flares being sighted across its surface. This activity is expected to reach its peak in the coming year or so, after which it will fall back into slumber once more, heading towards a new minimum. This pattern of rising and falling activity is known as the solar cycle.

"The solar cycle is driven by the magnetic field of the Sun," says Stephanie Yardley, a solar scientist from the University of Reading. "Approximately every 11 years the Sun's polar magnetic field reverses polarity – it swaps direction."

This swapping is a chaotic process, with magnetic field lines becoming tangled and churning up the plasma the Sun is made of, which we see as an increase in solar activity around the solar maximum. When the poles are holding steadily in place, there is little solar activity and we have a solar minimum.

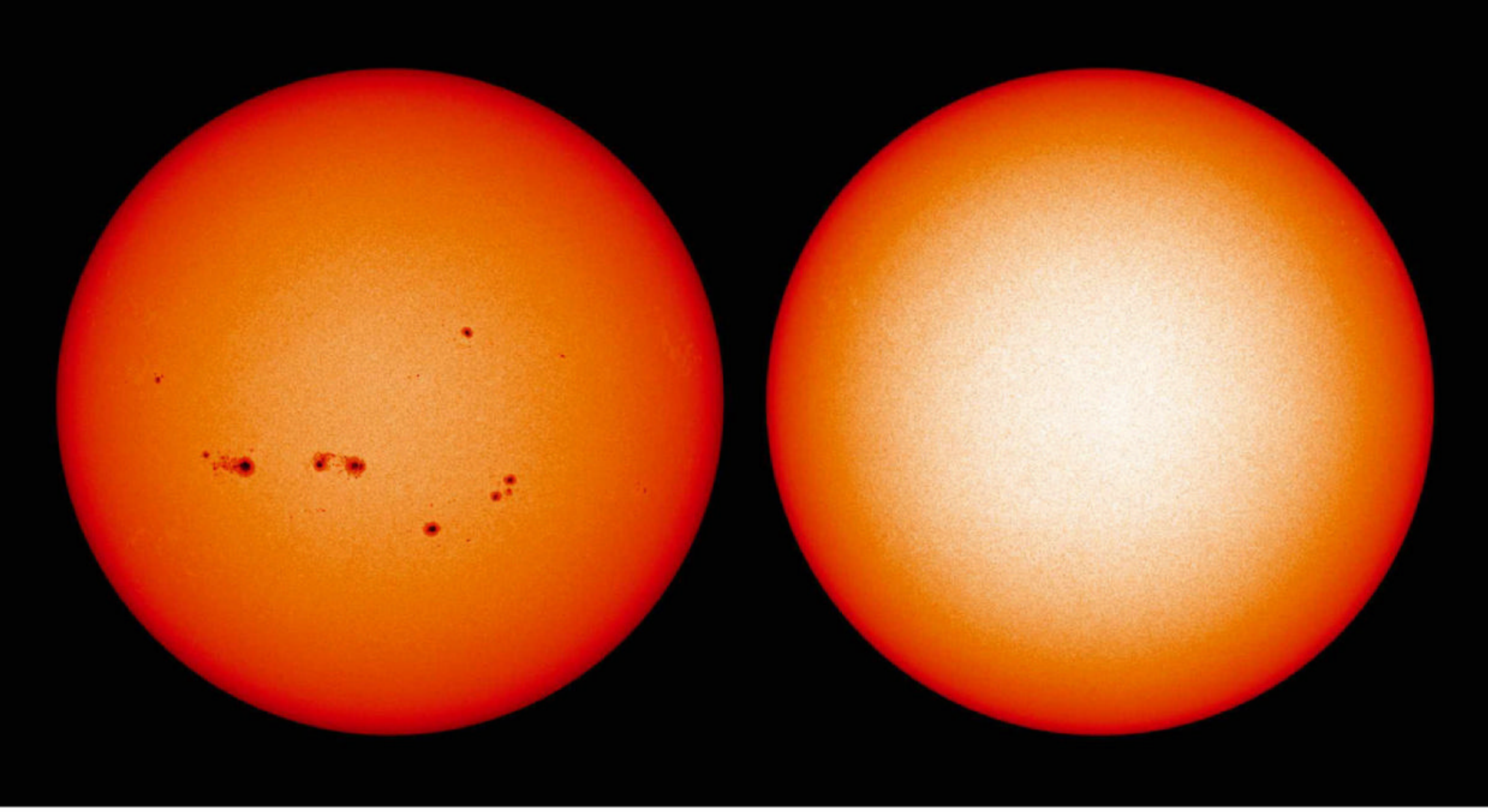
As the Sun's magnetic field is difficult to measure, astronomers instead track the solar cycle using something much easier to see: sunspots. They occur when a magnetic field line breaks through the visible surface of the Sun, preventing the hot plasma in a specific spot from mixing properly. This creates a cool patch, which we see as a dark blemish on the visible surface of the Sun. Astronomers track solar activity using a value called the sunspot number, which takes into account not just the number of individual spots, but how they are grouped together.

"We're currently in Solar Cycle 25, which is the 25th cycle since consistent records began in 1755, when extensive sunspot observations started," says Yardley.

Eccentric behaviour

In that time, the cycles have been far from consistent. Some solar cycles are as short as eight years between minima, others stretched out to 14 years. Solar Cycle 19 reached an all-time high sunspot number of 285 in one day in March 1958, ▶

NASA/SDO



▶ while historical records suggest there may have been virtually no sunspots seen between 1645 and 1715.

Since the 1980s, though, solar activity has been decreasing, with sunspot numbers dropping around 20 per cent every cycle. The previous cycle, Solar Cycle 24, was the lowest in a century and many astronomers predicted our current round would follow the trend.

"In April 2019, the Solar Cycle Prediction Panel met and suggested that the current cycle would be weaker than average, very similar to the previous solar cycle," says Yardley.

The panel was made up of solar experts from around the world, who used various methods to predict what our Sun would do in the coming years. Previously, the most reliable predictors have been those based on our understanding of the physical processes going on within the Sun.

"Solar minimum was predicted to occur between October 2019 and October 2020, with solar maximum being reached around July 2025, plus or minus six months, with a peak sunspot number of 115," says Yardley.

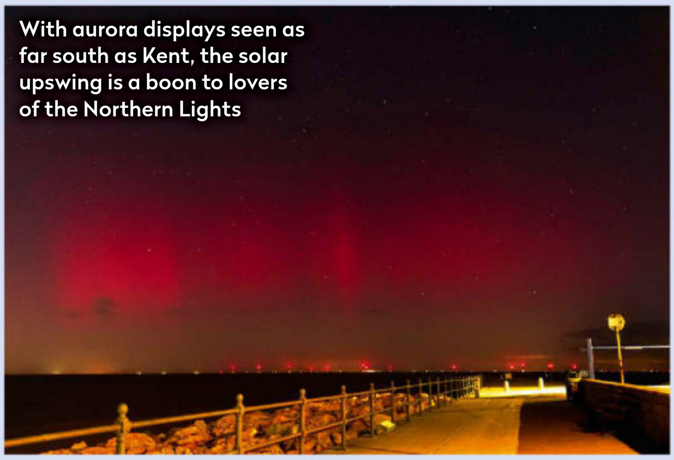
▲ **The Sun during the last solar maximum in April 2014 (left) compared with its appearance at solar minimum in December 2019 (right)**

A bumper time for the aurora

Increased solar activity could be fantastic for those seeking the Northern Lights

For those that don't have specialist solar telescopes or Sun-monitoring satellites, the most obvious way to see the swell of the solar cycle is via the aurorae. The Northern and Southern Lights are caused by solar wind particles getting trapped in our planet's magnetic field. Earth's field lines guide the particles down, forming a ring around either pole, known as the auroral oval, until they strike particles in our atmosphere, causing them to emit light photons, which we see as the aurorae.

Though they can occur at any time, the Northern Lights are best viewed between September and March, but good displays can happen in the months in between too. When solar maximum arrives (possibly as early as late 2023), your chances of a spectacular display will vastly improve as the increase in activity means more plasma is being thrown into space by the Sun.

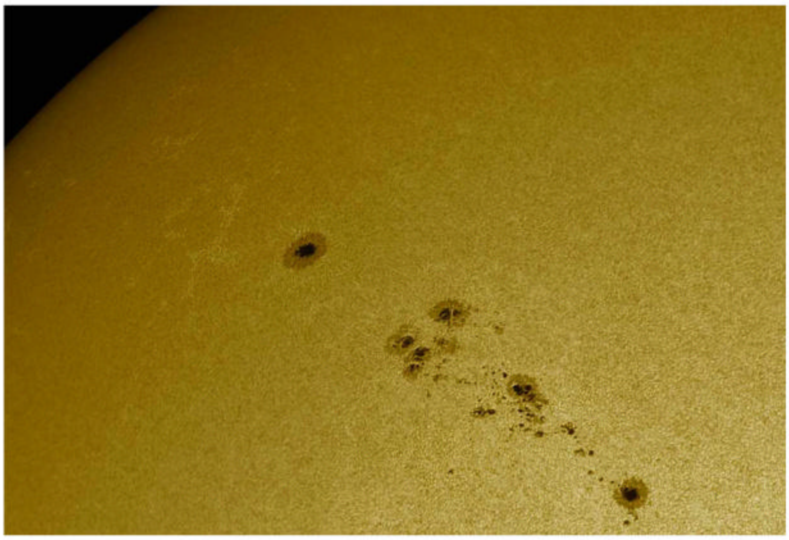


With aurora displays seen as far south as Kent, the solar upswing is a boon to lovers of the Northern Lights

"These eruptions, if Earth-directed, can cause dazzling displays of aurorae," says Yardley.

It can also push the aurorae to lower latitudes. Typically, the auroral oval sits between 60° and 75° latitude on Earth, covering northern parts of Canada, Norway, Sweden and Finland, and all of Iceland. However, strong eruptions can widen the auroral oval, so it covers lower latitudes.

"In the first half of 2023, there were reports of spectacular aurora sightings as far as southern England, due to Earth's magnetic field being heavily disturbed by the arrival of such eruptions," says Yardley.



▲ **Outbreaks of dark sunspots are one indicator of the Sun's activity ramping up. This region was photographed in May this year**

▼ **The densest regions of UV bright dots drift towards the equator, where they disappear, only for high-altitude sunspots to then sprout**

That would make it one of the weakest on record. However, not everyone was as convinced things would be so quiet. At the same time, another group was looking at a new way of measuring the cycle, one that predicted the Sun could be heading for one of the most active cycles ever seen.

Strange shifting spots

"A decade ago, we identified that the Sun did something really weird," says Scott McIntosh from the National Center for Atmospheric Research in Colorado. He and his colleagues have spent the last decade tracking the solar cycle not by looking at sunspots, but at much smaller spots that shine brightly at ultraviolet wavelengths.

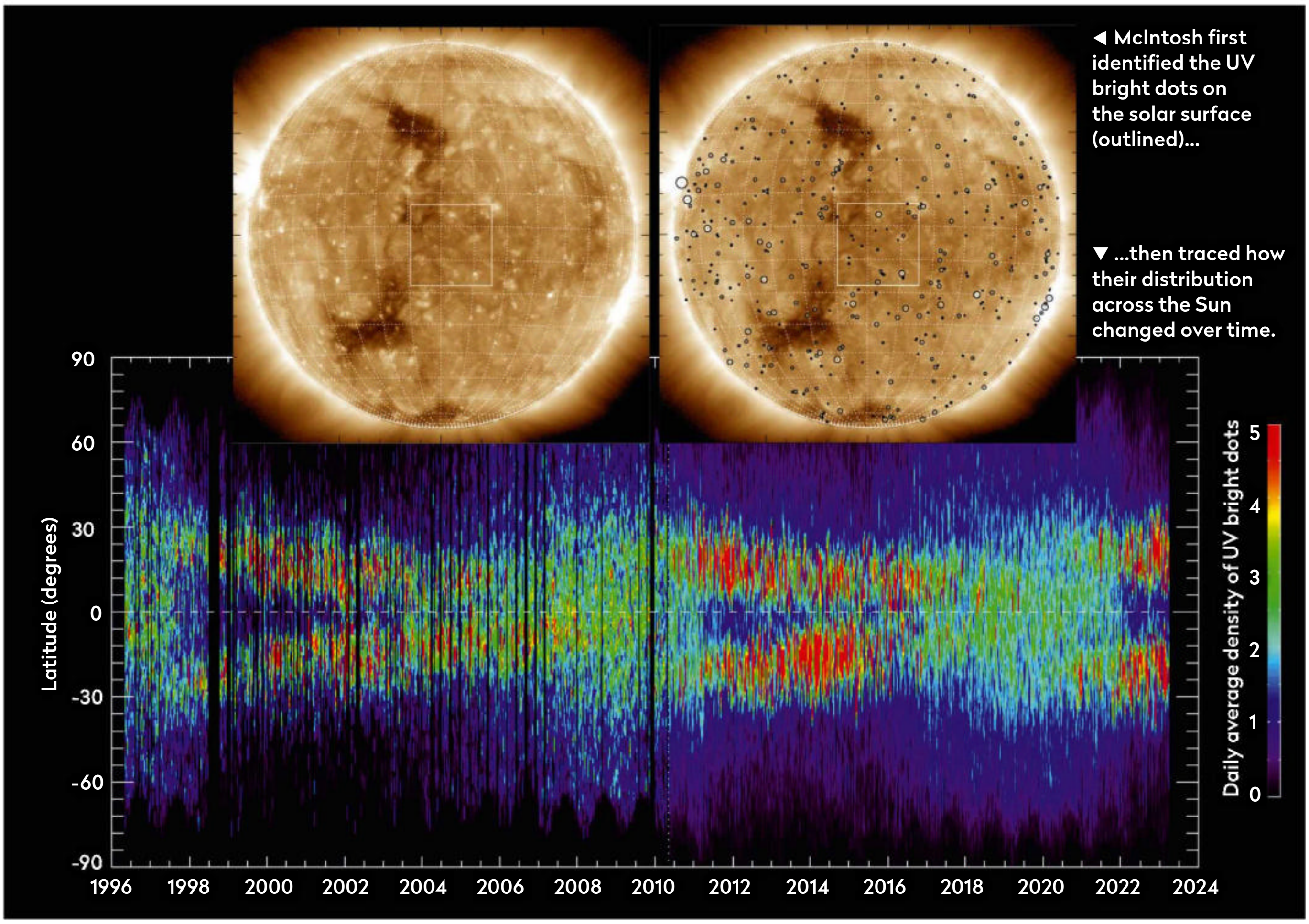
"They start at high latitude, around 55°, almost like clockwork every 22 years, and they take 19 years to get to the equator," explains McIntosh.

There are normally several bands of these spots drifting their way towards the equator from either side at any one time. When a north-moving and a south-moving band finally meet at the equator, the magnetic fields which cause them cancel each other out and vanish in what's known as a terminator event.

"When that happens, the bands at higher latitudes now mark out where sunspots will begin to appear," says McIntosh.

The precise physical connection between these observed events is unclear, but as sunspots occur when the Sun's magnetic field is out of balance, it would make sense that these terminator events could unbalance the scales enough to bring them about.

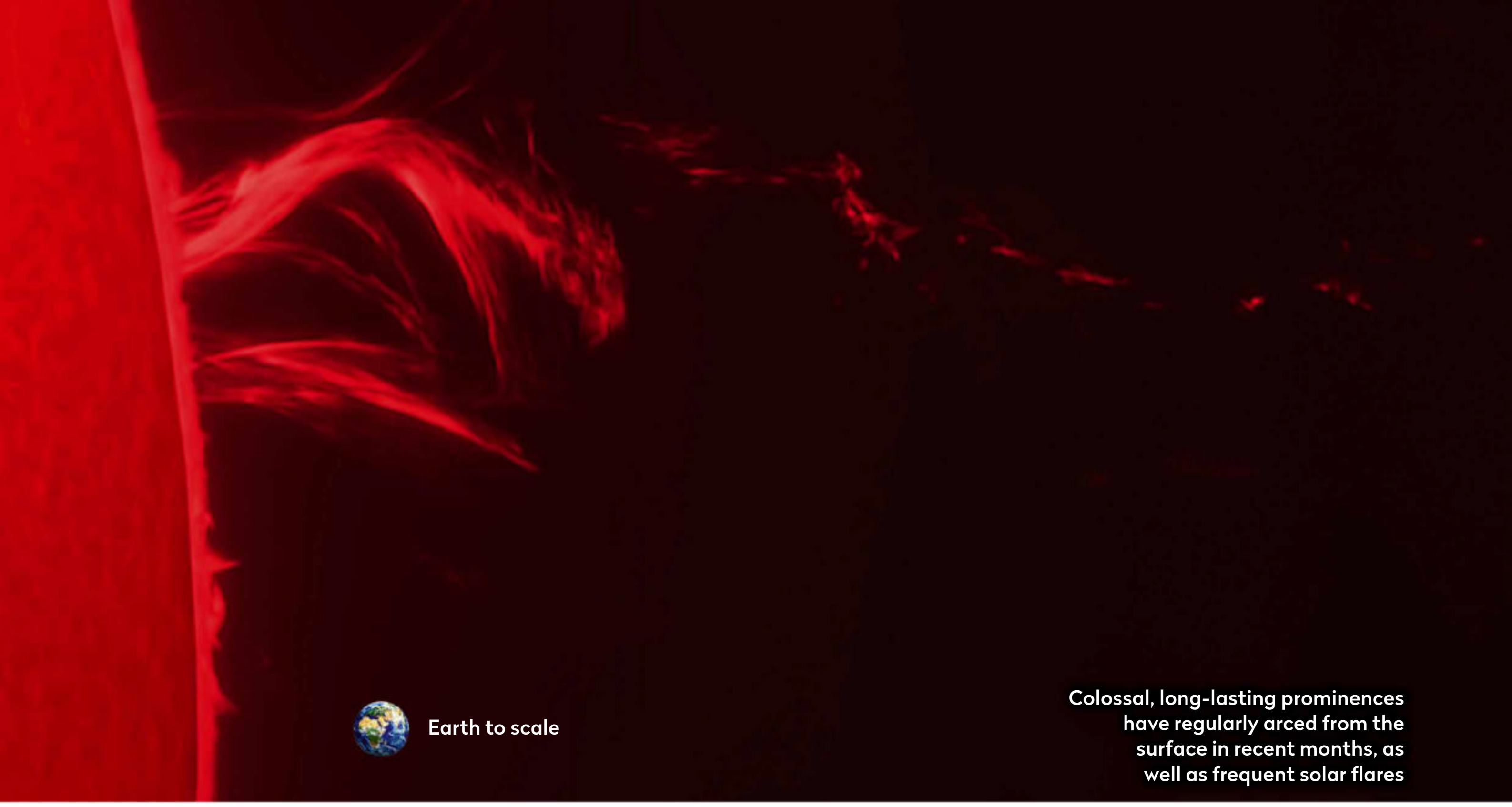
The ultraviolet bright bands don't move at a steady, uniform speed, so the exact time they take to drift down varies, but this usually means sunspots appear around 30° to 40° latitude. However, what really seems to matter when it comes to the solar ▶



◀ **McIntosh first identified the UV bright dots on the solar surface (outlined)...**

▼ **...then traced how their distribution across the Sun changed over time.**

NASA'S SOLAR DYNAMICS OBSERVATORY/JOY NG, JAMIE MCBEAN/ ALAMY STOCK PHOTO, PETE LAWRENCE, SCOTT MCINTOSH



Colossal, long-lasting prominences have regularly arced from the surface in recent months, as well as frequent solar flares

▶ cycle is how long it takes the terminator event to occur.

"The longer the delay in the terminator event at the equator, the more it eats into the development time of the next cycle," says McIntosh. "So if that separation is long, it means that the next cycle is weak. If the separation is short, [activity] would be high because you're giving the next cycle more time to grow."

In 2019, McIntosh and his colleagues looked at the bright spots and predicted a sunspot number of around 233, making it one of the most active on record. When the terminator event arrived in December 2021, they revised this prediction down to a more conservative 185, but this was still considerably higher than most other predictions.

Defying predictions

One of the biggest problems in predicting the solar cycle is that although solar astronomers know the 'flipping' magnetic field causes the cycle, they don't know what causes the poles to flip, or even fully understand the process which generates the field in the first place.

"We call the Sun the 'destroyer of scientific models'," quips McIntosh. "You think you've understood it and then five minutes later, you haven't."

The most recent best theory is that the motions of the Sun's rotating core create currents that generate the fields. But how this process works is still strongly debated, and conflicting predictions such as these are a golden opportunity to gain more insight into what's truly happening.

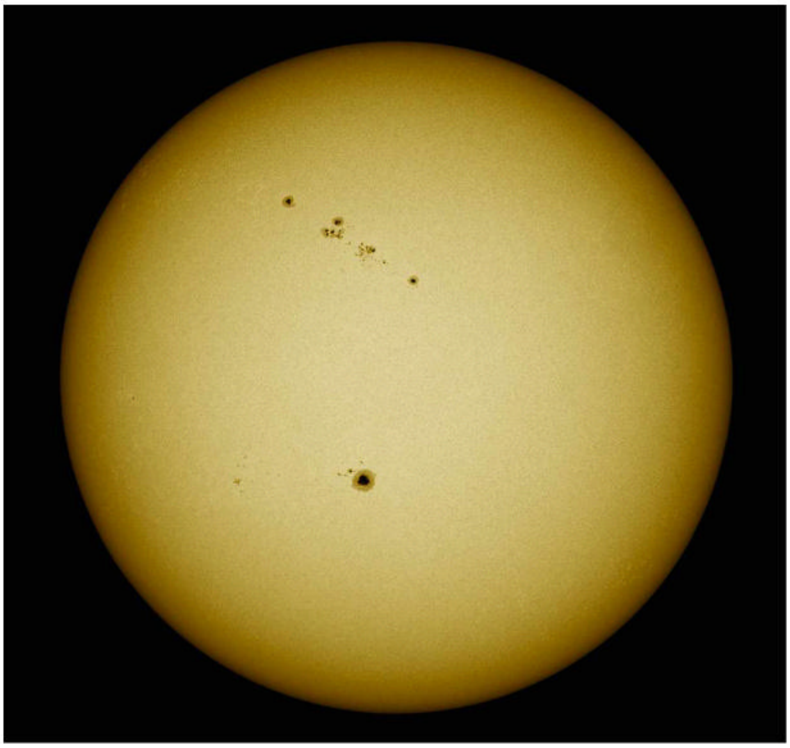
So, would Solar Cycle 25 see an all-time low in activity, or a record-breaking high? We are now racing towards the solar maximum, and the verdict is that Solar Cycle 25 is... average.

In May, the average monthly sunspot number recorded was around 138. While significantly higher than the predicted value of 75, and 40 to 50 per cent larger than at a similar time through Solar Cycle 24, it's not on track to meet the heady heights of the most active cycles on record.

That doesn't mean the Sun looks dull at the moment. Quite the opposite. As well as sunspots, there have been several eye-catching loops of solar material, known as prominences. There were also more solar flares in 2022 than even at the peak of the previous cycle, several of which have been the most energetic, X-class flares. All of this suggests that solar maximum could be heading our way much earlier than initial forecasts, sometime in 2024 or perhaps even by the end of the year.

Does this mean the solar predictors need to throw out their models and go back to the drawing board?

▼ Near solar maximum, sunspots are most highly concentrated around 30° to 40° latitude



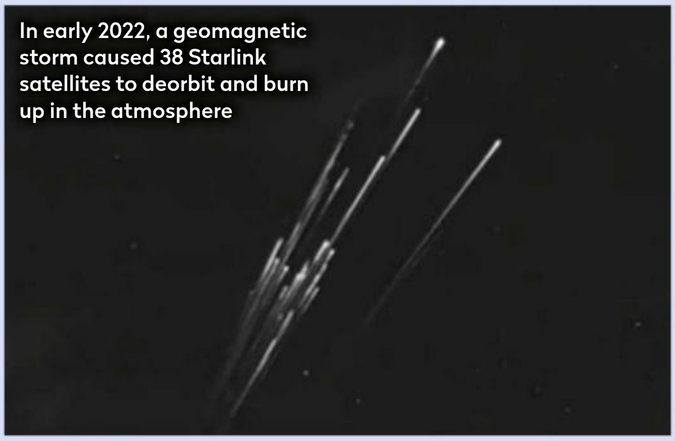
PETE LAWRENCE X 2, EDDIE IRIZARRY/SOCIEDAD DE ASTRONOMIA DEL CARIBE (SAC), ESA/ATG MEDIALAB

Forecasting space weather

The Sun's outbursts can have a massive impact for us here on Earth

Predicting the solar cycle is important not just to solar scientists hoping to learn more about our star, but is a practical concern for almost everyone on Earth.

Modern society is increasingly reliant on satellites to help us communicate, navigate and monitor our planet. When the Sun is highly active, it releases high-energy particles that can knock out electrical systems on satellites. Solar storms can even cause the atmosphere of our planet to expand. When this occurred in February 2022, just after a batch of SpaceX's Starlink satellites had been deployed into low orbit, the extra drag meant they were unable to reach their intended altitude and dozens crashed back to Earth.


In early 2022, a geomagnetic storm caused 38 Starlink satellites to deorbit and burn up in the atmosphere

Though our planet's magnetic field shields us from the worst of space weather, it can cause problems on the ground as well. Flares can create magnetic interference that blocks radio communications, as happened this June (see **page 14**). If a big enough storm hits Earth, it can cause electrical surges in power cables. Such a surge in 1989 caused a power outage that left 6 million people in Quebec in a 12-hour blackout.

Fortunately, operators can mitigate against these problems if they know a storm is coming. Space monitoring stations can give a few days' warning of an imminent storm, but being able to accurately predict when it might be particularly stormy would help them better prepare.

Ezzy Pearson is *BBC Sky at Night Magazine*'s features editor. Her book *Robots in Space* is available through History Press

Perhaps not, as most initial predictions were made a little prematurely, before the previous cycle had fully ended.

"The Sun ramping up much faster than forecast maybe isn't surprising in hindsight, given that solar minimum occurred near the beginning of the predicted range, in December 2019," says Yardley.

But one thing that both teams of solar astronomers agree on is that if we truly want to understand our star, then we really need to be able to get a broader look at the Sun.

"Previous studies have hoped they would find something between 30° and 35° latitude because that's where the sunspots appear," says McIntosh.


Solar Orbiter will photograph the Sun from closer than ever before, including its uncharted polar regions, reaching its steepest viewpoint in 2029

"But what if the pattern actually extends back to higher latitudes? 55° might be the place to go. Or around the poles."

Getting up close

The poles are where the magnetic field lines converge and become highly concentrated, making them key areas to understanding the magnetic field. Unfortunately, we can only glimpse the region at an oblique angle, when the Sun tilts towards Earth by around 7°. To get a better view, you need to get out of the plane of the Solar System and look down from above.

"During its extended mission, the orbit of ESA and NASA's Solar Orbiter will become increasingly inclined out of the ecliptic in order to image the polar regions for the first time," explains Yardley. "These observations could provide additional insight into the inner workings of our star, improving predictions of future cycles."

It will take Solar Orbiter many years and multiple planetary fly-bys to raise its incline, and even then its orbit will only be inclined by around 33° from the plane of the Solar System. Any better view will be up to a future mission.

"Our community is looking at opportunities for the next flagship-class missions," says McIntosh. "We need to plot a mission to the poles, to characterise the flows there and look for where the magnetic field forms and why."

Until then, though, there's really only one thing solar astronomers can do.

"We will have to be patient," says Yardley. "And take a watch-and-wait approach to see when solar maximum will occur and how strong it will be!"

The fundamentals of astronomy for beginners

EXPLAINER

Wild weather across the Solar System

Katrin Raynor looks at the extreme climates found on our neighbouring planets

▲ **It rains sulphuric acid and reaches 475°C – you'd certainly think twice before taking a stroll on Venus**

The climate on Earth is just right to support a rich diversity of life on land and in the oceans. The abundance of water, the warmth and energy from the Sun, and interactions within Earth's atmosphere create weather systems, while the motion of Earth gives rise to seasons. We do, however, experience extremes. Death Valley in Arizona holds the record for the highest air temperature recorded, in 1913 – a blistering 56.7°C (134.1°F) – and in 1983, the air temperature in Vostok, Antarctica, dropped to –89.2°C (–128.6°F). But if you think that's extraordinary, it's nothing compared to the rest of the Solar System!

Mercury

Mercury is the smallest planet in the Solar System and the closest to the Sun. It spins almost upright on its axis and doesn't have any seasons. Continually blasted by solar emissions – the Sun's rays here are around seven times stronger than on Earth – it experiences the most extreme temperatures of all planets. Due to its tenuous atmosphere, called an exosphere, rocky Mercury does not have weather systems. Temperatures can reach a scorching 430°C (806°F) during the day and at night plummet very quickly to a painfully cold –180°C (–290°F). However, despite being the closest planet to the Sun, Mercury isn't the hottest.

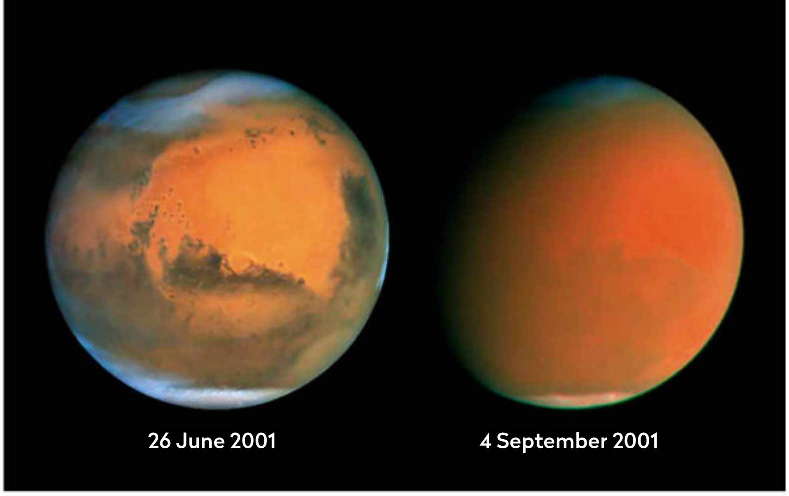
Venus

Our nearest planetary neighbour, Venus is the brightest planet seen in the night sky and holds the mantle as the hottest world. Its thick atmosphere and extreme greenhouse effect create a surface temperature of 475°C (885°F). The cloud cover is exceedingly dense, so sunlight can't easily penetrate through to the surface. The clouds reflect up to 84 per cent of the incoming rays from the Sun, which explains why we see it outshining most night-sky objects. Venusian clouds whip around the planet in days, due to atmospheric winds speeding at 350km/h (220mph), and release droplets of sulphuric acid that evaporate before reaching the planet's hot surface.

Mars

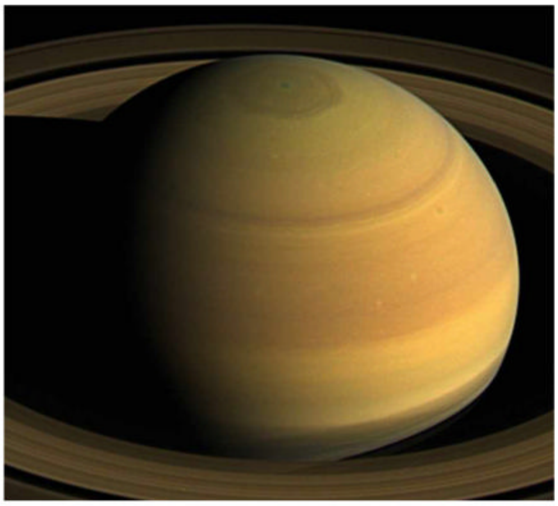
With canyons and hills, ice at its poles and riverbeds (albeit they dried up billions of years ago), Mars displays similar physical features to Earth. Unlike Earth, the Red Planet is unhabitable, lacking oxygen or any kind of substantial atmosphere that would help to sustain life. Dry and cold, the fourth planet

MARK GARLICK/SCIENCE PHOTO LIBRARY/ALAMY STOCK PHOTO, NASA/JPL-CALTECH/HUBBLE SPACE TELESCOPE, IMAGE DATA: NASA/JPL-CALTECH/SWRI/MSSS/IMAGE PROCESSING BY KEVIN M. GILL, NASA/JPL-CALTECH/SPACE SCIENCE INSTITUTE, NASA/JPL

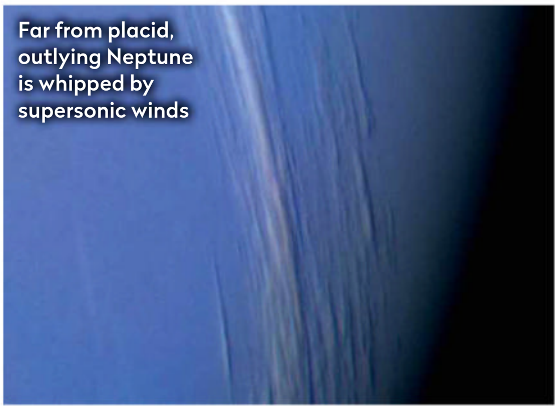


▲ **Martian dust storms can be so turbulent they take over the entire planet, shrouding it in dust for weeks and causing temperatures to soar**

▲ **Gas giant Jupiter is a cauldron of perpetually swirling storms. Its biggest, the Great Red Spot, has ravaged the planet for centuries**



▲ **Saturn is another tumultuous gas ball, though its solid moon Titan gushes with methane rivers and seas**



Far from placid, outlying Neptune is whipped by supersonic winds

from the Sun is infamous for gigantic, prolonged dust storms, storms so big they can be viewed through a telescope from Earth. These last for days and rage around the planet at up to 106km/h (66mph), reaching heights of 1,000m (3,000ft) and covering areas the size of continents.

Jupiter

Jupiter is the largest planet, a gas giant with a huge gravitational pull that has captured over 80 moons. At the equator, a belt of reflective clouds shines brightly while winds hit speeds of 402km/h (250mph). Jupiter's famous Great Red Spot – a high-pressure anti-cyclonic weather system, twice the size of Earth and over 16,000km (10,000 miles) wide – has been raging for over 300 years. It is the planet's main distinguishing feature and the largest storm in the Solar System. There is no solid surface to slow this raging storm down and, despite shrinking since at least the 19th century, there is nothing to indicate that it won't remain indefinitely into the future.

Saturn

Ringed planet Saturn takes only 10 hours to complete one rotation, generating wind speeds of up to 1,600km/h (1,000mph). A 32,186km-wide (20,000-mile) hexagonal jet stream exists at its north pole. Its atmosphere is composed of hydrogen and helium, with tremendous electrical storms persisting for months. Titan, Saturn's largest moon, is quite spectacular. It exhibits a cycle like Earth's water cycle but instead of water, it's composed of methane. Titan has a weather system created by a dense atmosphere trapping heat and wind. Liquid methane rain lashes down on its surface creating an abundance of rivers and seas.

Katrin Raynor is an astronomy writer and a fellow of the Royal Astronomical Society

Uranus

You would assume that Neptune is the coldest planet because it's furthest from the Sun, but it's actually ice giant Uranus that takes this crown. Temperatures on Uranus have been recorded as low as –224°C (–371°F). Receiving only a small percentage of sunlight, Uranus's penetrating cold is caused by its axis lying parallel to its orbital plain – in other words, it spins on its side. This extreme axial tilt causes intense seasons lasting 21 years. In 2006, the Uranus Dark Spot was observed on the planet's surface, a swirling vortex so big it would engulf two thirds of the United States.

Neptune

Neptune is the outermost planet and takes around 165 Earth years to orbit the Sun. Exhibiting processes similar to Uranus, its serene blue appearance is misleading – Neptune is one of the wildest planets of all! The weather on Neptune is driven by a combination of heating from its core, cosmic rays and ultraviolet radiation from the Sun. These factors form cirrus-like clouds composed of frozen methane and generate winds of 2,100km/h (1,300mph) which produce powerful storms, including a dark, oval anti-cyclonic storm like Jupiter's Great Red Spot, called the Great Dark Spot, that moves at a breathtaking speed of 1,200km/h (750mph).

FAMILY FRIENDLY PROJECT

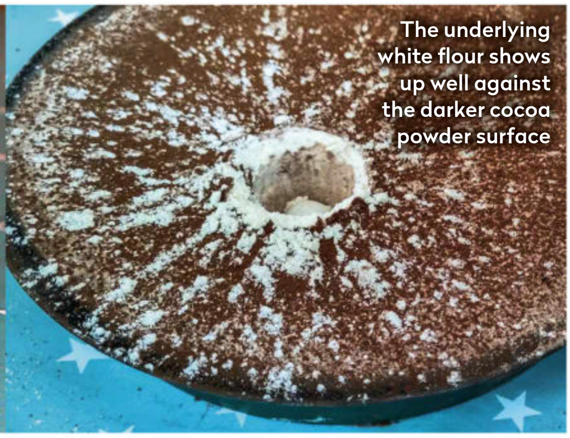
Practical astronomy projects for every level of expertise

DIY ASTRONOMY

Make your own lunar impact craters

This fun activity for the whole family brings to life the drama of meteor impacts on the Moon

Smash! The moment of impact caught on camera



The underlying white flour shows up well against the darker cocoa powder surface

This simple activity provides a good introduction to how lunar craters and their surrounding features are created, and it's great fun for all the family to get involved with.

Craters are formed when an asteroid, comet or large meteorite hits the surface of a planet or moon. These objects can be travelling at speeds of up to 40 kilometres per second, so the impact is violent and the energy released can dramatically change the landscape around it within seconds. The crater itself is usually circular, but in some circumstances oval-shaped craters can form.

Commonly seen features include a raised rim around the edge of the crater, unstable material slipping down on the inside edge to form slump terraces, a blanket of ejecta material from below the surface that extends outwards by 2–3 crater diameters, and ejecta rays – such as you'll see around craters like Copernicus and Tycho – which are straight lines of subsurface material that may extend out for a huge distance from the crater.

Brace for impact!

Lunar impact craters are usually 10 to 20 times larger in diameter than the object that created them, but the ones we create won't be that large because we can't throw our impactors at the speed needed for such a dramatic effect! However, we'll still be creating craters with very similar features to those that you can see on the Moon.

Mary McIntyre is an astronomy educator and teacher of astrophotography

Flour is an ideal material for this project because it mimics the behaviour of lunar surface material that has been pulverised by a violent impact. It is very lightweight, so it produces great ejecta features that stand out when a darker layer of cocoa powder is used as a surface covering.

Make sure to cover the floor around the cake tin with a plastic or vinyl sheet to catch any stray material. Your tin needs to be at least 4–5cm deep, otherwise your impactors will hit the bottom and bounce up again, creating an unnatural crater.

When it's time to drop your impactors, it's helpful to hang a makeshift plumb line from the ceiling so you can centre the cake tin underneath. Once the tin is in place, you can shorten the string so the end is 1 metre above the floor. If you then hold your impactors at the end of the string before dropping them, you can be sure that they're all falling from the same height. After you've made all your drops from that height, shorten the line so the end is 1.5 metres from the floor and drop the impactors from there.

If you photograph or sketch each crater and its features after impact, you can easily compare the differences created by different sizes of impactors and different heights.

What you'll need

- Air-dry clay or Plasticine for making different-sized impactors
- White flour – any kind will do. Alternatively, you could use fine white sand instead
- Cocoa powder and a small sieve to create the top layer of your lunar surface that has a colour contrast with the flour layer
- Deep cake tin or oven tray. We used a 4cm-deep circular tin with a diameter of 20cm
- A ruler that is longer than the diameter of your cake tin so you can easily level the top of the flour with one swipe

ALL PICTURES: MARY MCINTYRE

Step by step

Step 1

Create some impactors by rolling the air-dry clay into different-sized balls and letting them dry. We made four, with diameters of 1cm, 1.5cm, 2cm and 3cm. If you don't have clay, you can use Plasticine or similar material instead.

Step 2

Fill your cake tin with white flour or fine white sand, being careful not to pat it down and compact it. Using a ruler, scrape across the top to create a level surface. We did this step over a plastic box to make the clean-up easier.

Step 3

Using a small sieve or tea strainer, gently sprinkle some cocoa powder over the flour to create a thin and even covering across the entire surface. Then position your tin on the floor, on top of the plastic or vinyl sheets.

Step 4

Drop the smallest impactor onto your lunar surface from a height of 1 metre. Take photographs or make sketches of the resulting crater and note any features you see. Carefully remove the impactor, fill in the hole and reset the surface.

Step 5

Repeat step 4 for the other three sizes of impactor, noting any new features that appear with the larger impactors compared to the smaller ones. Photograph or sketch each new crater, then remove the impactor and refresh the surface before each drop.

Step 6

Repeat step 4, but this time drop your impactors from a height of 1.5 metres. Photograph or sketch the results you get from each of the larger impactors. Note how the increased height affects the height of the crater rim and the spread of the ejecta.

Take the perfect astrophoto with our step-by-step guide

ASTROPHOTOGRAPHY CAPTURE

Image a fisheye Milky Way

Ultra-wide-angle lenses capture our Galaxy crossing the whole sky. Here's what to consider

▲ **Ultra-wide-angle lenses cover large areas of sky, but one drawback is that constellations may appear underwhelming**

The night sky can be breathtaking, especially when it contains bright views of the Milky Way from a dark-sky location. But what's the best way to capture the entire stretch of the night sky? There are several methods, but as ever compromises have to be made.

A camera with an interchangeable lens system such as a DSLR or mirrorless camera gives you the best of all worlds, allowing you to go wide-angle or mid-angle. A wide-angle lens has a focal length of 17mm or less, a mid-angle is 18-40mm. Anything over this is getting in too close to the subject to be considered all-encompassing.

If you choose a mid-angle focal length, you'll be able to cover a decent portion of the Milky Way, but you'll need to consider mosaicking shots together to cover all of it. However, seemingly perfect shots can then reveal issues such as lens distortion and edge vignetting, so be prepared to put significant time into a Milky Way mosaic in order to get something that looks natural.

Pete Lawrence is an expert astro-imager and a presenter on *The Sky at Night*

An alternative is to use a wide-angle lens, essentially capturing most of the visible part of the Milky Way in one fell swoop. It seems an obvious choice to reduce workload, but wide-angle lenses have drawbacks of their own.

As with meteor photography, using a wide-angle lens may seem the ideal route – catching a trail is down to luck, but the narrower the field of view, the less chance of success. So it seems a no-brainer to choose a lens that covers the entire sky in one go.

However, unless you're lucky enough to grab a bright fireball tracking over most of the sky, a typical meteor trail will appear rather puny and unimpressive. In addition, extreme wide-angle or fisheye lenses have a tendency to distort around the edge of frame both spatially and in terms of image finesse. By spatially we mean the angular scale at the centre of the frame will be different to that at the edge. Finesse refers to the quality of the image towards the frame edge and affects things like the tightness of stars and whether they actually look like stars!

Another wide-angle compromise is the amount of sensor utilised. True fisheye lenses deliver a circular image. This either fits and underutilises the whole sensor area or does fill the sensor by cutting off part of the fisheye's image. Typically, an 8–10mm focal-length lens produces an image that fits circularly on a full-frame sensor. A 12–18mm will fill the sensor frame while cropping a bit of the fisheye's image.

A long session outside with a fisheye lens requires careful placement of any dew-reduction kit, whether this is a passive lens dew shield or an active dew heater strap. If you don't pay attention to where you put these, it's easy for them to end up as a pseudo false horizon.

Equipment: DSLR or equivalent, wide-angle lens, driven equatorial mount

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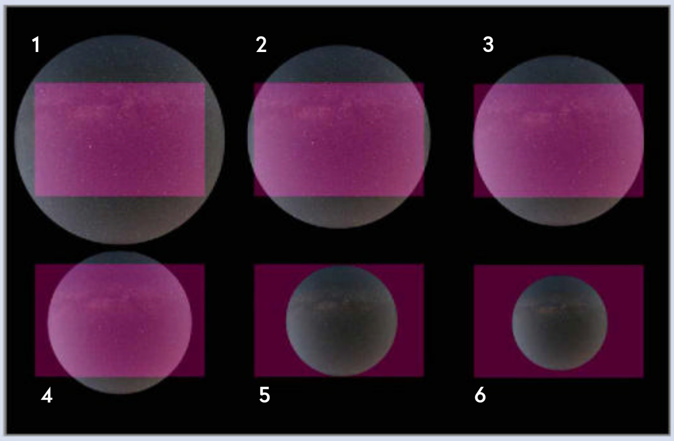
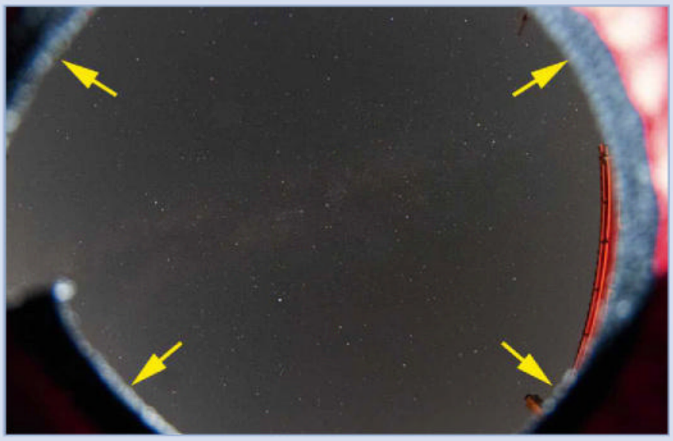
Step by step



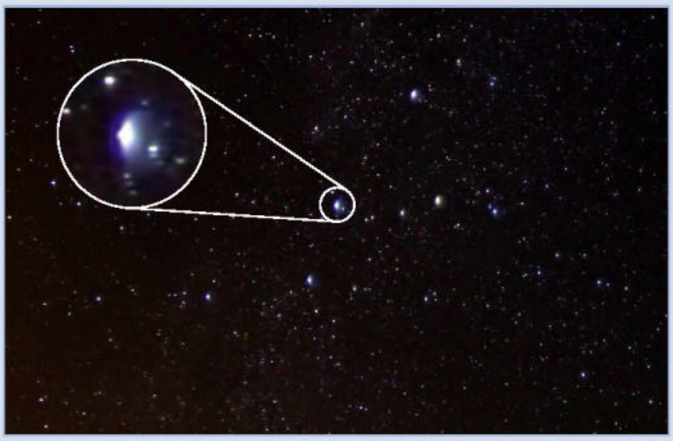
STEP 1
Look to balance sensor vs fisheye coverage. 1. Whole sensor used, but fisheye heavily cropped. 2. Sensor corners unused, fisheye cropped. 3. Sensor corners unused, fisheye fully utilised in one axis. 4. Sensor and fisheye underutilised. 5. Fisheye fully used, sensor underutilised. 6. Poor use of sensor and fisheye.

STEP 2
Mount the camera on a tripod; there's no need for star tracking with a fisheye. Fully open the lens, focus accurately and carefully point at the zenith. This part can be tricky – any offset may cause less sky and too much horizon to show. The camera's live view option is useful, although the screen position will be awkward!

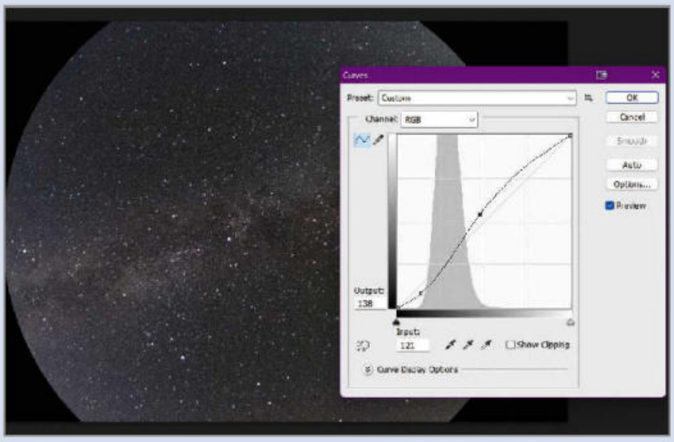


STEP 3
If you're considering dew prevention with a dew shield or dew heater band, place them carefully so they don't appear in the field of view. Take a test shot and examine any signs that the lens is picking up something it shouldn't. If it is, remove the dew shield or move the heater band back towards the camera body.

STEP 4
Set a low to mid ISO and take a test exposure. To minimise star trailing, adhere to the '500 rule', which states that the longest exposure you can take without star trails becoming obvious is equal to 500 divided by the focal length of your lens. For example, for a 14mm lens, 500/14 = 36 seconds.



STEP 5
Examine a test exposure. A bright but not overexposed sky is acceptable, but if you feel it's too bright, look at the quality of the edge stars. If they look seriously out of focus or an odd shape, close the lens by a stop or two. If the quality is fine, reduce ISO. If necessary, consider reducing the exposure time as well.



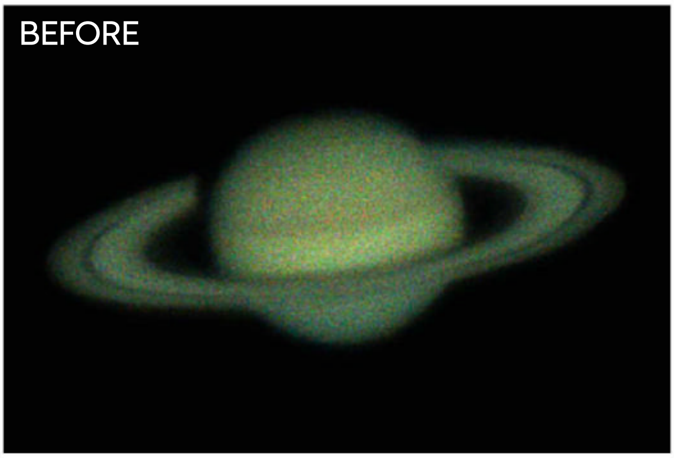
STEP 6
Edit your resulting photo as you would any deep-sky image. Creating a basic S-curve using a curves tool can work wonders. You can apply corrections if your images appear heavily distorted. Programs such as Photoshop and GIMP (freeware) offer lens correction filters to adjust this.

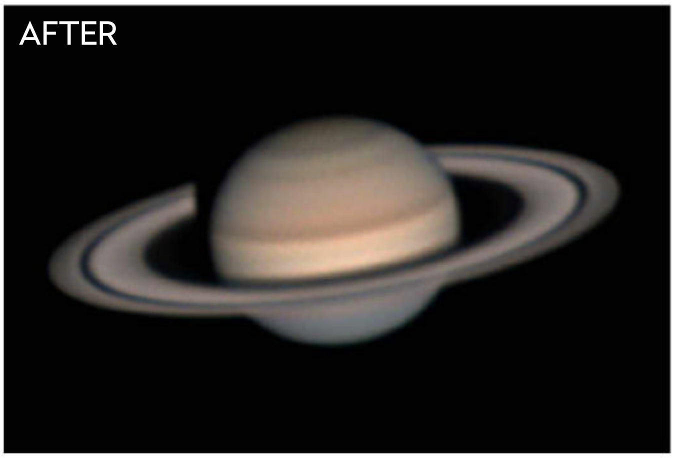
Expert processing tips to enhance your astrophotos

ASTROPHOTOGRAPHY PROCESSING

Create your best image of Saturn

Great pictures of the ringed planet start as video, before stacking and processing



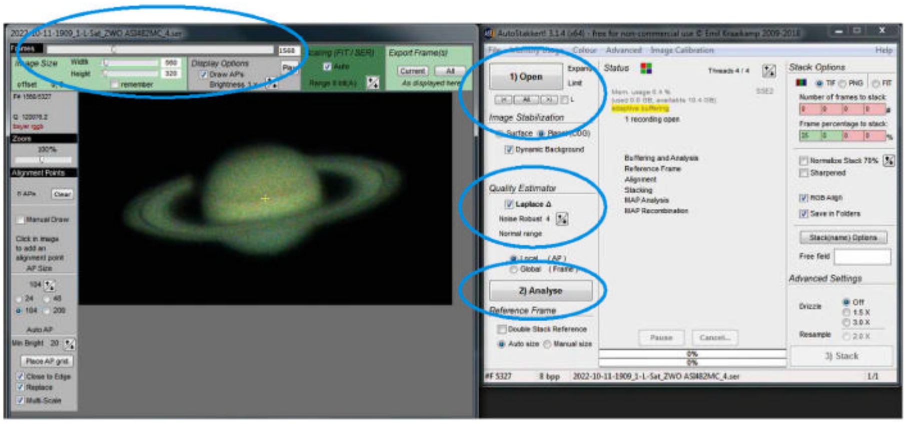


▲ **Left: the best single frame from Martin's original video. Right: the final image after stacking and boosting the colour and brightness**

The best way to produce your own full-colour image of Saturn is to first capture a correctly focused and exposed video of the planet, a minute or so long, using an astronomical digital camera at the focus of your driven telescope. Here I'll explain how you then process this video to create a single final image of the planet; I'll assume you are using a colour digital video camera as this is the easiest way for you to produce a full-colour image.

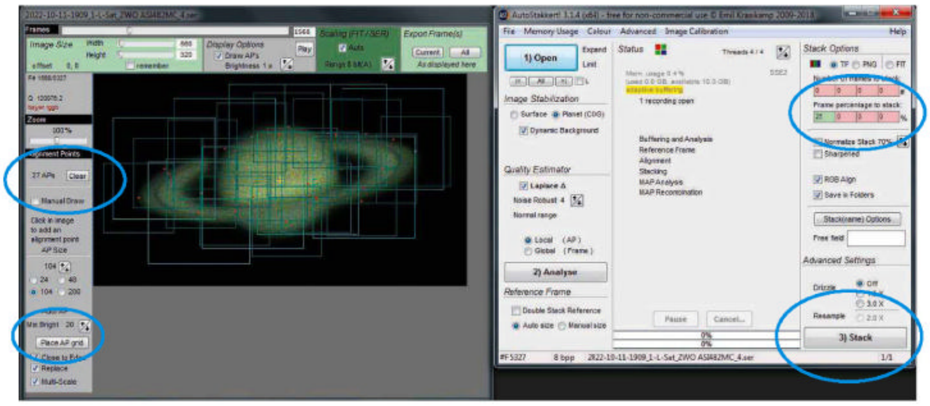
At the processing stage, you use special software to break your video down into separate frames, rate each frame for quality, then align the best ones so that they all lie exactly on top of one another. This results in a single-frame stack. This stack is effectively a long-exposure image made up of lots of carefully aligned single, short exposures. The long exposure averages out the chaotic movement in our atmosphere and also means the noise is much reduced compared to the much shorter-exposed individual frames. This allows stretching and local contrast enhancement methods to be applied that would be pointless for the much noisier single frames.

You may be surprised that a single piece of freeware called AutoStakkert! can accomplish all of the initial stages described above. Download and install the latest version of AutoStakkert! from **www.autostakkert.com/wp/download**. Start the program, click 'Open' in the control box and import your Saturn video. Select the settings so that your screen looks like that shown in screenshot 1. Next, hit 'Analyse' to sort through the



▲ **Screenshot 1: In AutoStakkert!, click 'Analyse' to sort through and assess your frames. Move the top slider to check that the program has ordered them correctly from best to worst. Tweak the 'Noise robust' setting and re-do the 'Analyse' process if necessary**

ALL PICTURES: MARTIN LEWIS



▲ **Screenshot 2: Click 'Place AP grid'. We used 27 in this example; click 'Clear' and retry if there are too few or too many alignment boxes. Set the percentage of frames that you want to keep. Click 'Stack' and wait for the program to stack your best frames**

3 QUICK TIPS

1. Record videos when the air is stable and still, such as when high pressure is present, as the seeing will be better then.

2. For best functionality, record your videos in SER format using the camera control programs FireCapture or SharpCap.

3. In AutoStakkert!, adjust the planet edge overlap of alignment boxes by clicking 'Close to edge'.

frames and assess each one for the presence of planetary detail. Once this is complete, move the slider at the top of the preview window to go through the frame sequence, which will now have been ordered from best to worst. Check that the planet is stationary as you move the slider and that the progression is indeed from good at the start to bad at the end. To reduce noise, alter the 'Noise robust' setting, trying higher values for more noisy frames or lower values for less noisy ones, then re-analysing until you best accomplish this progression.

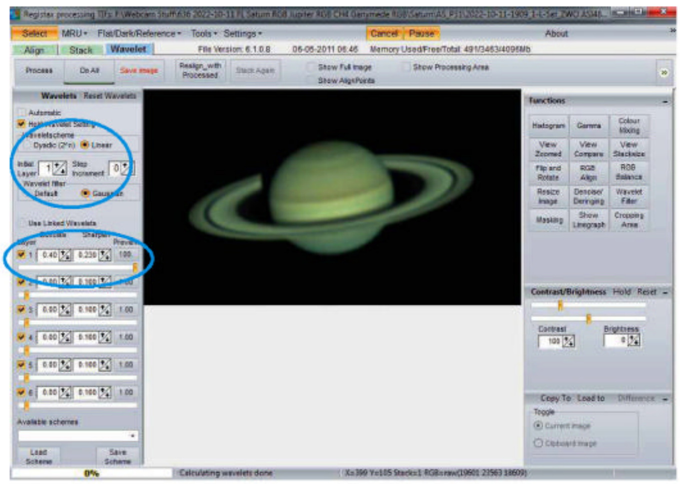
Boxing clever

The next step is to set the alignment points for the stacking process. To the left of the preview screen, pick a size of alignment box and click 'Place AP grid' to auto-place the boxes. You want about 10–30 alignment boxes over the planet, as shown in screenshot 2. If there are too many or too few, hit 'Clear' and retry with larger or smaller alignment box sizes. You are now almost ready to stack. First, set the percentage of frames you want to keep and enter this in the upper right corner of the control box. Enter a value like 25 per cent for average seeing, then click 'Stack' to initiate the alignment and stacking of the best frames. This may take a while for a large video, so be patient. Once done, the result will be auto-saved.

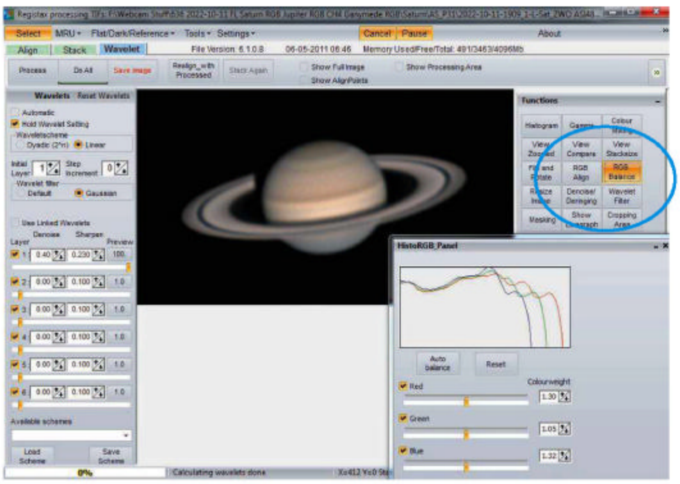
You are now ready to stretch the local contrast to bring out the detail. This is done in RegiStax 6, another piece of free astro software. Download and install it from **www.astronomie.be/registax**, then hit 'Select' and open the image previously saved by AutoStakkert! RegiStax will then jump straight to the 'Wavelet' processing tab. Here, select 'Linear' and 'Gaussian' as shown in screenshot 3, and move the slider in the top level to 100 per cent. Next, increase the 'Sharpen' value in this top level a little, to bring out the contrast; this will increase the noise, so then increase the denoise value too. Play around with these two values until you have a sharp and smooth final image. It's tempting to overdo it and stretch the contrast too much, so try to keep it natural-looking, even if that means holding back a bit on the sharpening.

The final steps are to use the 'RGB balance' button (see screenshot 4) to get the colour balance correct and boost the brightness. For Saturn, the right colour for me means the inner, bright ring (known as the B ring) is essentially grey, so move the three RGB sliders to achieve this and boost the brightness until the brightest colour is just short of the right-hand end of the RGB histogram window. Finally, save your final finished image of the ringed planet.

Martin Lewis is an expert astronomer and award-winning planetary imager who also builds his own telescopes



▲ **Screenshot 3: Open the now-stacked image in RegiStax. Select 'Linear' and 'Gaussian'. Move the slider to 100 per cent and tweak 'Sharpen' and 'Denoise' values until you get a sharp, smooth image**



▲ **Screenshot 4: Make final adjustments to the colour and boost the brightness of your image by clicking 'RGB balance' and moving the sliders. Choose grey for the planet's inner, bright ring**

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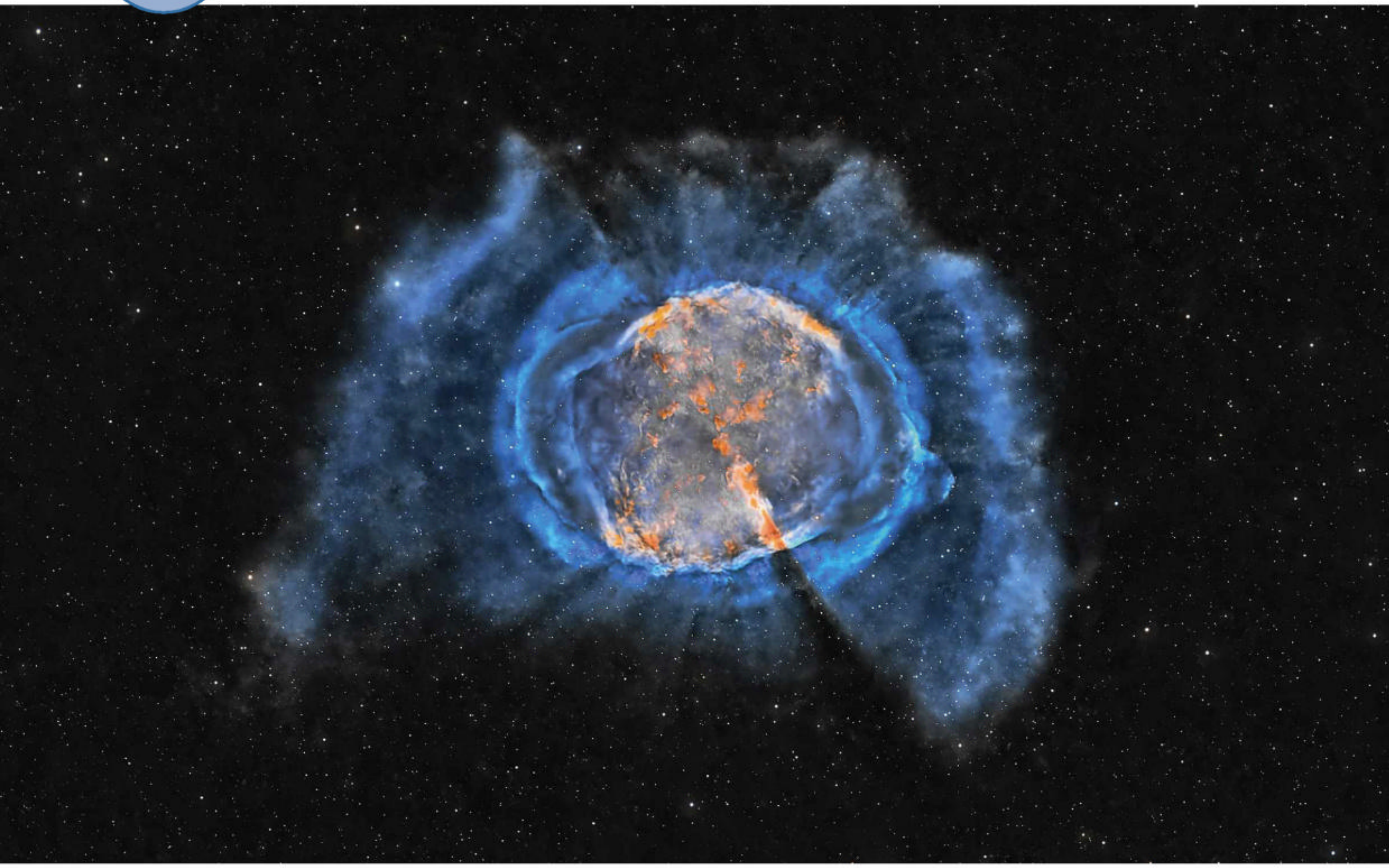


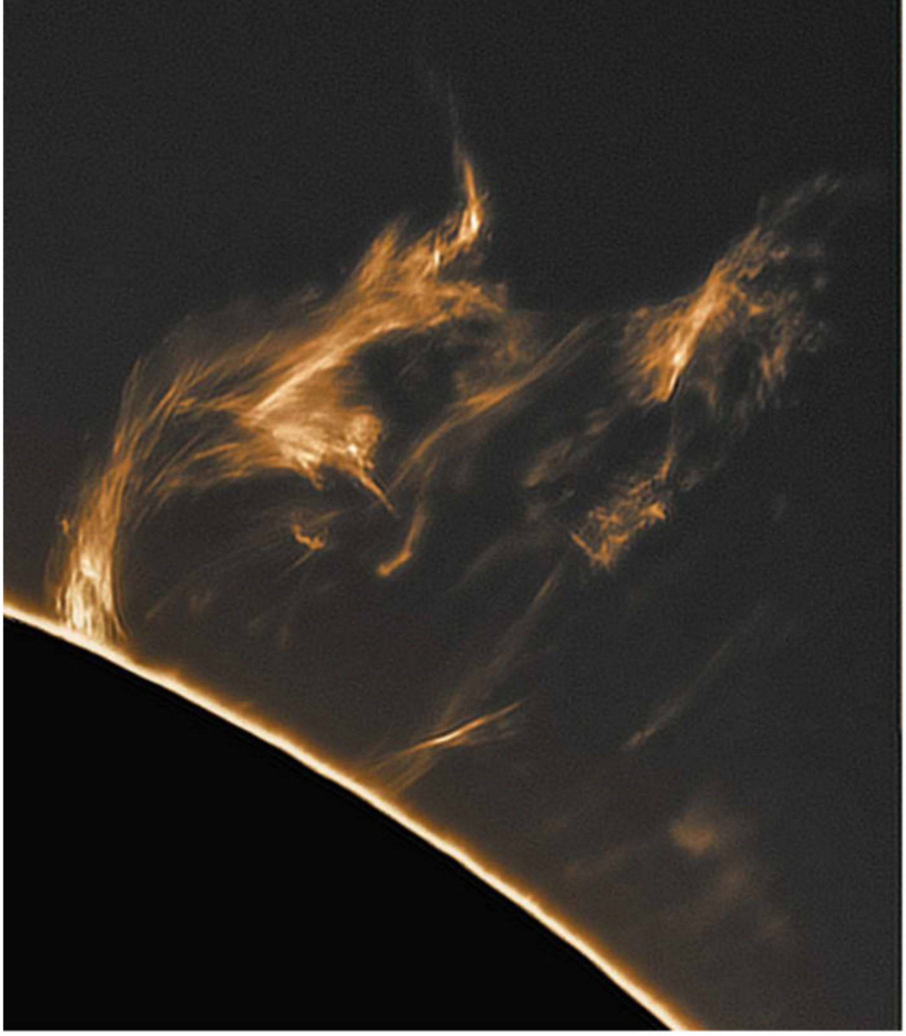
△ M27, the Dumbbell Nebula

Patrick Cosgrove, Honeoye Falls, New York, USA, 2–4 August 2021

Patrick says: "M27 was a childhood favourite. I wanted to see what detail I could capture of the outer gas shell, so I photographed this in narrowband in 2021. I was amazed at how different the individual Ha, OIII and SII images were from one another! More recently, I went back and enhanced the detail in the outer shell, which provides a very different view of M27."

Equipment: ZWO ASI2600MM Pro camera, Astro-Physics 130mm f/8.35 StarFire EDT refractor, iOptron CEM60 mount
Exposure: 39x 300' Ha, 28x 300' OIII, 46x 300' SII
Software: PixInsight, Photoshop

Patrick's top tips: "Anyone interested in deep-sky imaging should consider starting with a shorter-focal-length scope and a one-shot colour camera. This is smaller, lighter, more affordable, simpler to use and more forgiving of common setup and capture errors. Focus on learning the basics of data capture – this is the foundation for everything – and work methodically at your own pace. Trying to go faster will just frustrate you! The next challenge is image processing. The learning curve here may not ever end – tools and your skills will improve all the time, so hold on to all your data so you can reprocess again down the road!"



◁ Coronal mass ejection

Gordon Harrison, Derby, 27 May 2023

Gordon says: "Summertime is solar time and any clear day is an imaging day! I'd recorded a few sunspots and increased the gain to show any prominences. After recording the few that were visible, I couldn't resist a last sweep before ending the session and was stunned to see this coronal mass ejection. An amazing sight – I'm really pleased to have captured it."

Equipment: Altair GPCAM3 290M camera, Altair 72 EDF refractor, Sky-Watcher HEQ5 Pro mount
Exposure: Best 50 frames from 1,000
Software: SharpCap, AutoStakkert!, ImPPG, Photoshop

▽ Venus

Dmitry Ardashev, Zaprudnya, Russia, 29 April 2023

Dmitry says: "I've been wanting to shoot clouds in the atmosphere of Venus for a long time. Visibility that evening was good. I used a 685nm infrared filter for the red channel and a ZWB2 365nm ultraviolet filter for the blue, then selected 3,000 of the best shots in each channel."

Equipment: QHYCCD QHY178M camera, TS-Optics UNC 10-inch Newtonian, Sky-Watcher EQ6-R mount
Exposure: 3,000x 54fps video frames (UV), 3,000x 84fps video frames (IR) **Software:** AutoStakkert!, RegiStax, Photoshop

△ Full Moon over the Castle of Evoramonte

Sérgio Conceição, Evoramonte, Portugal, 6 May 2023

Sérgio says: "This picture, taken from a distance of 6.3km, captures the full Moon behind the Castle of Evoramonte, which is located between the cities of Évora and Estremoz. Once of great geographic and military importance, the 16th-century fortress feels like an ancient warrior who patiently awaits visitors with countless stories to tell them."

Equipment: Canon EOS R mirrorless camera, Canon EF 100–400mm f/4.5–5.6L IS II USM lens
Exposure: ISO 800, f/5.6, 1/20"

△ IC 4592, the Blue Horsehead Nebula

Drew Evans, Flagstaff, Arizona, USA, 24–27 May 2023

Drew says: "The Blue Horsehead Nebula was one I'd been wanting to shoot for years, but lacked the dark skies and clear view of the southern horizon to do so. I spent almost 20 hours acquiring data to produce this image, which came out remarkably well."

Equipment: ZWO ASI2600MM Pro camera, Askar V60 refractor, ZWO AM5 mount **Exposure:** L 51x 300", R 51x 300", G 51x 300", B 51x 300" **Software:** Astro Pixel Processor, PixInsight, Lightroom

▽ Mars and M44

David Hoskin, Halifax, Nova Scotia, Canada, 31 May 2023

David says: "I was delighted when a clear, transparent sky allowed me to photograph Mars as it approached the Beehive Cluster, just after sunset on the last day of May."

Equipment: Canon Rebel T3i DSLR camera, William Optics RedCat51 refractor, Sky-Watcher Star Adventurer mount **Exposure:** 22x 30" **Software:** Sequator, Photoshop, StarNet++, GraXpert

△ The Moon

Ian Wardlaw, Washington, Tyne & Wear, 29 May 2023

Ian says: "I'd gone out to do some astrophotography, but as the Moon was bright I decided to take a few videos using my Altair camera, which I hadn't used for several years. I took eight videos to make a detailed mosaic. I think it turned out well. It hasn't been over-sharpened, so the Moon's features look good."

Equipment: Altair Hypercam 183MC camera, Meade LX200 8-inch Schmidt-Cassegrain
Exposure: 8x 1' videos
Software: AutoStakkert!, PixInsight, Photoshop

The Iris Nebula ▷

Steve Thexton, Burton in Kendal, Cumbria, April 2023

Steve says: "I'm pleased with this for a relative beginner in a back garden in Cumbria. It's down to greater integration time and being further along the steep PixInsight learning curve."

Equipment: ZWO ASI2600MC Pro camera, Celestron 9.25-inch Edge HD aplanatic Schmidt, Sky-Watcher EQ8-R Pro mount **Exposure:** Mix of 30", 180" and 300", total 14h **Software:** PixInsight, Photoshop

▽ M83, the Southern Pinwheel Galaxy

Behyar Bakhshandeh, Descanso, California, 20 May 2023

Behyar says: "I'm happy with the way it turned out, but it did take some light deconvolution to tame the star bloat."

Equipment: FLI ML6303 mono camera, Deep Sky Instruments RC10C Ritchey-Chrétien astrograph, Astro-Physics AP900 GTO mount
Exposure: L 90', R 40', G 40', B 40'
Software: CCDStack, Photoshop

△ Strawberry Moon

Kimberley Noton, Hindhead, Surrey, 4 June 2023

Kimberley says: "Arriving at Gibbet Hill, we saw the Moon rise in beautiful red tones. It was difficult taking an image in between the gusts of wind, but luckily by adjusting my position and view I managed to capture this image of the Strawberry Moon."

Equipment: Canon EOS R mirrorless camera, Canon RF 800mm f/11 IS STM lens, Benro tripod
Exposure: ISO 6400 f/11, 0.2"
Software: Lightroom

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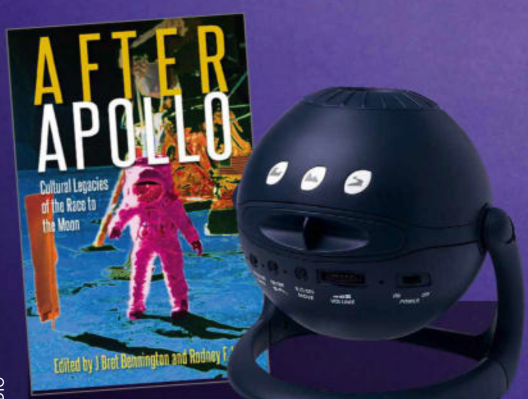
It's definitely bigger, but is it better? We test out Askar's largest-aperture refractor



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Our experts review the latest kit

FIRST LIGHT

Askar 130PHQ flatfield apo refractor

If you've got the budget, this hefty refractor's got fine views and a deluxe feel

WORDS: CHRIS GRIMMER

VITAL STATS

- **Price** £3,989
- **Optics** Air-spaced apo quadruplet (two ED lenses)
- **Aperture** 130mm
- **Focal length** 1,000mm, f/7.7
- **Focuser** CNC-machined, dual-speed rack and pinion
- **Extras** Tube rings, dovetail bar, finder-scope bracket, carry case, 2-inch eyepiece adaptor, camera adaptors
- **Weight** 10.2kg; 12.5kg with supplied case & accessories
- **Supplier** First Light Optics
- **Email** questions@firstlightoptics.com
- **www.** firstlightoptics.com

Following in the footsteps of Askar's successful 107PHQ flatfield apo, we take a look at its bigger brother, the 130PHQ. Arriving in a single, very large box, the first thing we noticed about Askar's largest-aperture refractor was the weight, so we were glad we didn't have to carry it too far! Opening the box revealed a substantial and extremely robust carry case, with the telescope held very securely inside. Upon removing the telescope, we found the included adaptors located in their own compartments underneath. In keeping with the colour scheme of other Askar PHQs, the tube was finished nicely in white with black and green accessories.

The 130PHQ has a very professional feel to it, with everything made from machined aluminium and zero plastic. The fit and finish is exceptional; we even had to remove the lens cover to extend the dew shield because it fitted so well that it created suction. But, once the lens cover was removed the dew shield slid smoothly into position and was retained securely by a thumb screw. The large-barrel focuser is silky-smooth and claims to be able to handle up to 8kg in weight, enough for most users' needs. The focuser is also fully rotatable and, again, the fit on this is excellent.

Style and substance

The 130PHQ on its own weighs 10.2kg, with the carry case and supplied accessories making a combined weight of 12.5kg. It was quite apparent this is a telescope that will require a substantial mount to do it justice. As well as its weight, at 1,061mm with its dew shield extended, it's a long tube. Given these two vital statistics, the carry handle on top of the OTA made the telescope surprisingly easy to move around and gave additional security when lifting onto our mount.

Once mounted, we found that balancing on the declination axis was straightforward. Unlike its smaller counterparts, the 130PHQ was nose-heavy ▶

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SCALE

Focuser

To allow for use with cameras that have large-format sensors, the 130PHQ is equipped with a 3.4-inch, solid metal, dual-speed rack and pinion focuser. The larger barrel reduces the risk of vignetting, while being robust enough to take even the heaviest of cameras.

Dew shield

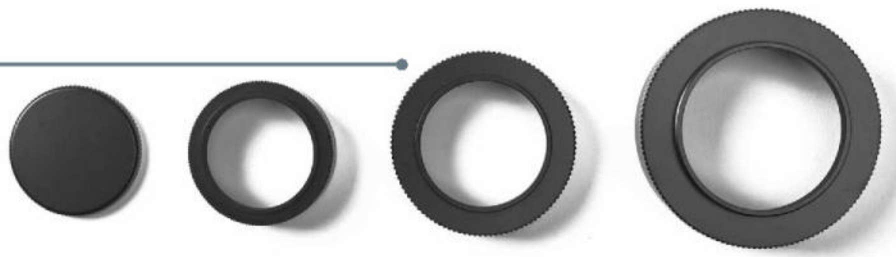
The 130PHQ is equipped with a large, retractable dew shield. Fully constructed from aluminium, it easily extends into place and is secured by a thumb screw, eliminating any risk of it slipping during an imaging session.

Tube rings/bar

The 130PHQ is equipped with solid aluminium tube rings. Attached to the bottom of these, finished in striking green, is a 300mm Losmandy dovetail bar that ensures the telescope can be easily balanced. On the top of the rings is a very useful carry handle that makes mounting and dismounting the telescope an easy task.

Adaptors

Askar includes four adaptors that allow for a range of different cameras and accessories to be attached directly to the focuser, providing a wide range of options for astrophotographers. The adaptors are M68 x 1mm, M54 x 0.75mm, M52 x 0.75mm and M48 x 0.75mm, all male threaded.



No flattener required

The Askar 130PHQ is a quadruplet telescope with a main objective lens that's a generous 130mm in aperture. There's a triple-lens cell up front with two ED glass lenses. The benefit of ED glass is it helps to focus all three colour channels, giving better colour correction. The fourth lens is situated at the centre of the tube and is the integrated field flattener.

The advantage of the four-element design, then, is that no additional field flattener is required. With normal field flatteners, the space between the back of the flattener and the image sensor is critical, with just a millimetre of discrepancy potentially affecting the final image. This can result in the need for multiple extenders and a lot of work getting the spacing perfect. With the Askar's fourth lens element acting as a flattener, there is no special requirement for camera spacing, which makes initial setup easier and quicker.

▶ due to its large front lenses, which meant that with cameras and accessories attached, the balancing point is around the middle of the telescope. To balance in the right ascension (RA) axis on our Sky-Watcher EQ6-R mount required two counterweights positioned at the very end of the counterweight bar.

Imaging capabilities

With darkness arriving, we slewed up to M81 and M82 in Ursa Major, making the most of the 1-metre focal length to target some galaxies. Using the included thread adaptors, we were able to attach our Canon 6D directly to the focuser and could achieve focus without the need for additional spacers. We found this to be easy, thanks to the very smooth and solid-feeling focuser, which allowed precise, tiny adjustments to be made. While we did notice some image shift when changing direction, this didn't cause us any issues during our imaging session. Throughout, the focuser showed no signs of slippage.

The 130PHQ has a 60mm image circle designed for medium-format cameras, so we were very impressed

KIT TO ADD

1. Askar 0.7x reducer

2. Pegasus NYX-101 harmonic gear mount

3. Askar 32mm guidescope

Travel case

Included as standard with the 130PHQ is a solid travel case. Fully padded, it holds the telescope securely with tube rings attached, allowing for convenient and safe storage when not in use or when transporting the telescope. There is also space under the scope to store the included adaptors.

▲ The 130PHQ was paired with a Canon 6D using the included adaptors for this image of galaxies M81 and M82. 92x 30" exposures

◀ Stars stayed sharp even into the far corners of Markarian's Chain. 72x 30" exposures

with how good the stars were into the very far corners and how slight the vignette was on the full-frame DSLR. With everything set up, we set our DSLR to run for an hour, capturing 30-second exposures. Downloading the images the following morning reconfirmed our initial positive impressions of image quality and flatness of the field, which made final processing easy. It also confirmed the focuser had maintained perfect focus across the night of imaging, despite a 15° Celsius temperature drop from warm spring day to cold spring night.

With its weight and size placing it at the top end of the amateur market, Askar's 130PHQ flatfield apo refractor is a telescope that will not fail to impress the most advanced imager. It may not be as portable as the 107PHQ, but what it lacks in portability it more than makes up for in quality. Askar has again produced a quality astrograph.

VERDICT

Build & design	★★★★☆
Ease of use	★★★★☆
Features	★★★★☆
Imaging quality	★★★★☆
Optics	★★★★☆
OVERALL	★★★★☆

iOptron HAE29 harmonic drive mount with iPolar and tripod

A light, no-nonsense, big-payload dual-mode mount with electronic polar scope

WORDS: TIM JARDINE

VITAL STATS

- **Price** £2,298 (mount), £275 (iOptron CF tripod)
- **Mount type** Strain wave, equatorial/altaz
- **Load capacity** 13.5kg (18kg with optional counterweight)
- **Slew speed** 9 speeds, up to 8° per second
- **Power** 12v DC 5A
- **Autoguider port** ST4
- **Handset** Go2Nova 8409 with inbuilt Wi-Fi
- **Protocols** ASCOM, INDI, iOptron Commander
- **Weight** 3.6kg
- **Supplier** Altair Astro
- **Email** info@altairastro.com
- **www.** altairastro.com

Astronomy mounts with harmonic drives have special gear systems rather than the usual worm gears and have become a bit of a trend recently, being smaller and lighter for their weight-carrying capacity. iOptron has now introduced a new one, the HAE29 with iPolar, which uses strain wave gears in its right ascension and declination axes, and has both equatorial and altazimuth modes.

It comes as a package, the mount head itself and the necessary accessories for it all neatly contained within a lightweight carry case. When matched with the iOptron carbon-fibre tripod, the whole assembly can easily be carried, making it ideal for a portable setup and perfect for travelling astronomers.

Setting up the mount is an absolute doddle, with just two bolts attaching the head to the tripod, and they are stowed on the head itself when not in use, along with the necessary Allen key – a very handy touch. The mount runs on a 12V DC power source; a standard AC mains indoor type PSU is supplied, but as it only draws 0.6A when tracking and 1.0A when slewing, it should run for quite some time on a portable power pack.

Keen to try some guided astrophotography, we chose to set the mount up in equatorial mode at first, with our 75mm refractor and CCD camera. After inputting our site details, date and time into the hand controller, we manually set the mount with a rough polar alignment and then did it precisely with the iPolar electronic polar scope. This attaches to the front of the mount with thumbscrews and plugs into a computer via a USB cable. Using the downloadable software, we were precisely aligned in a few minutes. The iPolar device can be removed after this. Again, the minimal time required for setting the mount up really impressed us, as there's nothing worse than fiddling about on a clear night trying to get equipment working instead of actually using it!

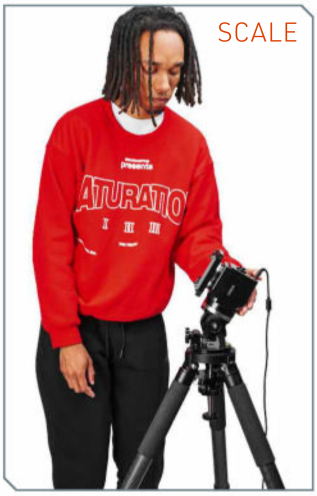
Under control

The HAE29 can be controlled in a number of ways, offering ASCOM, INDI and Wi-Fi options. There's an ST4 port for guiding, but we just connected to our ▶

Smooth and quiet

Harmonic drive, or strain wave gears, enable the HAE29 to carry a hefty payload of 13.5kg with no need for a counterweight to balance it. Thanks to the automatic electronic friction brake system, there is no manual clutch on either axis – and no worries about the mount swinging around if the power fails. If required, an optional counterweight bar and a 4.5kg weight can be added to increase the payload to a sizable 18kg, enough for a chunky Celestron C11 telescope plus camera gear.

On the technical side, the RA axis motor has a 480:1 reduction ratio, while the dec. axis motor has a 360:1 reduction ratio. There's a printed test report in the case, showing the movement of the HAE29 over its 360-second cycle. This reveals a smooth wave with no jumpy errors and a total peak-to-trough reading of 31.93 arcseconds. We were able to take 10-minute exposures with autoguiding. We found the HAE29 motors to be very quiet in operation with our telescope and camera attached, which had a combined weight of around 6kg.



iPolar electronic polar alignment

The iPolar device uses software-based live image plate-solving to work out the position of the mount, then provides an on-screen, intuitive display to manually polar align the mount using the azimuth adjusters and latitude adjustment knob. This was a quick and simple process.

Dual mode: altaz and equatorial

By adjusting the latitude bolt, the mount can be quickly swapped between altaz and equatorial modes, after changing the setting in the handset. Telescopes with either Losmandy or Vixen-style dovetail bars can be used, as the saddle can be altered to accommodate either type in just a few seconds.

Tripod

The iOptron carbon-fibre tripod is only 60cm long when folded and provides a sturdy base, 94cm high with legs fully extended. It weighs just a shade over 2kg and thanks to the large rubber feet and carbon fibre legs, quickly dampens any vibrations, giving steady views at the eyepiece.

Go2Nova 8409 handset

The handset allows control of the mount with a comprehensive database of objects built in, including the Messier catalogue. It also produces a Wi-Fi signal, allowing phone or tablet control of the telescope via apps such as SkySafari or iOptron's Commander Lite, and has a USB connection for computer control.

Padded case

The carrying case has a firm shell and foam padding inserts and safely contains the mount head, handset, iPolar device, 12v PSU and USB cables, along with the printed pictorial Quick Start Guide. With all of these inside, the weight of the bag is around 5kg and it's easily carried with the ergonomic handle.

▶ laptop via the mount's inbuilt Wi-Fi, which had a good strong signal that didn't falter during our whole review period. It readily connected with PHD2 for guiding and we set about gathering some photos, starting with the North America Nebula, NGC 7000, then M27, the Dumbbell Nebula. The equipment ran seamlessly over several hours and, again, it was really gratifying to just have the kit chugging along with zero interference required.

Our skies were a little murky, with high cloud affecting the seeing. There was a little bit of wandering between each guide star exposure, which may have been the mount, the seeing or a bit of both; but it's interesting that there's a higher-spec 'EC' version of the HAE29 available which has high-accuracy encoders on the RA axis. At any rate, the stars in our images were reasonably tight and round, and we were pleased with the end results.

With regards to visual astronomy, the HAE29 is pretty much a grab-and-go mount. We used it in altaz mode for observing and then photographing some prominent sunspots, and at night for globular clusters. Using the handset for this, we were surprised to find there is no alignment routine for altaz mode. This meant we had to set the mount's initial position with a compass to get accurate Go-To results.

Our reviewer was pleased with the reasonably sharp stars in the Dumbbell Nebula, 9x 10' exposures

▲ Under poor seeing conditions, the North America Nebula wandered a little in the view. 5' exposures, 1h 35" total. Both images taken with an Atik 460EX camera and Pentax 75mm SDHF

The handset is on the petite side, so we found it easier to connect to SkySafari on our phone and navigate with that. Once we had achieved alignment, tracking ability was impressive: the mount held targets in the centre of our 13mm eyepiece over several hours and accurately – and very quietly – slewed to each Messier target on our list.

Overall, we found the HAE29 to be lightweight, fast to set up, accurate and easy to use for observing or astrophotography – perhaps the ideal partner for hassle-free astronomy.

VERDICT

Assembly	★★★★★
Build & design	★★★★☆
Ease of use	★★★★☆
Go-To accuracy	★★★★☆
Stability	★★★★★
OVERALL	★★★★☆

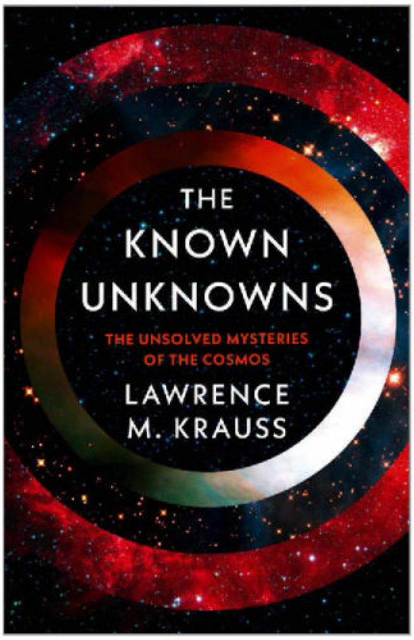
KIT TO ADD

1. Altair 70 EDQ-R F5 quad apo astrograph

2. iOptron counterweight shaft

3. iOptron 4.5kg counterweight

BOOKS



The Known Unknowns

Lawrence M Krauss
Head of Zeus
£20 ● HB

In astronomy there are things we know we don't know about – the known unknowns. These are often what get scientists the most excited as they hold the potential for a new discovery.

In cosmology, there are many things that we know we don't know the answers to, such as the beginning of time, the end of the Universe and whether physics has its limitations. These are just some of the questions that Lawrence Krauss explores in *The Known Unknowns*.

The book is split into five chapters, each with an overarching topic: time, space, matter, life and consciousness. The latter two aren't often found in conjunction with cosmology, but as each chapter is fairly distinct, these subjects don't feel out of place. There are plenty of links back to the familiar; for example, a discussion of different techniques to find habitable planets harks back to the question of whether we are alone in the Universe. The book also contains up-to-date discussions, such as the science potential of the James Webb Space Telescope.

Within each chapter, the author identifies several questions to be discussed. Somewhat frustratingly, however, these are only mentioned at the outset of the chapter. As the author goes on a lot of tangents, it is easy to forget that the last several pages were about how consciousness arises, for instance. Parts of the book are also written from the author's perspective and opinion, which at times feels a little forced. Given the subjects explored in the book, it's oddly ungripping, and the layout does not lend itself to finding an answer to the questions easily. Sometimes explanations end and refer the reader to another of the author's books, which is an unwelcome advertisement.

The ideas explored in *The Known Unknowns* do make the reader appreciate that there is still much to explore and wonder about within the study of cosmology; for instance, what about the unknown unknowns?

To quote from the book: "Imagination in nature far exceeds that of humans, so unless we keep probing it, the known unknowns will never change". ★★★½


Life on other worlds and whether we're alone in the Universe are among the questions pondered

PPL58/ISTOCK/GETTY IMAGES

Laura Nuttall *is a Future Leaders Fellow at the University of Portsmouth*

Interview with the author
Lawrence M Krauss

How important is the phrase "I don't know"?

It's central to science. More parents and teachers need to be comfortable saying this to young people, as it invites you together to try and discover what might be known, or try and resolve the unknowns. Education becomes a voyage of discovery instead of rote learning. "I don't know" invites discussion and opens your mind to consider the perspectives of others. This dialectic keeps science vibrant.

What missions are you looking forward to?

The James Webb Space Telescope will open up new vistas and help potentially resolve questions about the early Universe and the possible existence of life elsewhere. New technologies in the quantum realm will open up quantum computing to potentially take us in new directions of understanding. The ability to manipulate biological molecules will change how we understand the nature of life. The ultimate problem of understanding consciousness is perhaps most perplexing of all and may require us to explore consciousnesses that we may create in the future, as exciting and possibly terrifying as that may be.

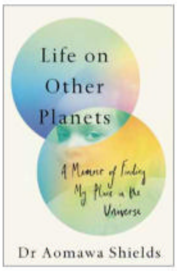
Could humans ever know everything?

The answer is simple: "I don't know." That is what makes science, and life, so exciting. There is no evidence that there are fundamental limits on our understanding, but we will never know if we stop asking questions and searching for answers.

Lawrence M Krauss *is a theoretical physicist and president of the Origins Project Foundation*

Life On Other Planets

Aomawa Shields
Constable
£22 ● HB



Aomawa Shields is many things: an astronomy professor, a classically-trained actor, a PhD, a mother, a Black woman in STEM, a poet and a teacher. Her memoir is the story of her life, but throughout it she is in conversation with the reader. Can you relate? She asks. Do you remember? Her story is one of reconciling different loves – astronomy and acting – that maybe aren't so different after all.

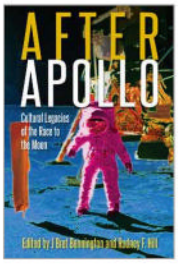
Shields began a career in astronomy in the 1990s, getting partway through a PhD programme before the theatre beckoned and she left to earn an acting MFA. A decade, a marriage and a role in 2005 film *Nine Lives* later, astronomy called out to her once more. In her absence, the field had exploded with the discovery of exoplanets, and it is this topic she explored as she finished her PhD and worked her way up to a position as a professor at University of California Irvine, where she studies the habitability of red dwarf systems, particularly the effects of exotic forms of ice on planetary climates. Championing interdisciplinarity, Shields looks for life in the Universe while using her acting skills and warm personality to share her enthusiasm with others. This riveting memoir is relatable and personable, especially to those readers who must also balance academia with other passions.

As Shields says in the book, science and art don't just complement each other: they overlap. She is part of that overlap. Are you? ★★★★★

***Emma Johanna Puranen** is a postgraduate researcher in exoplanet science*

After Apollo

Edited by J Bret Bennington & Rodney F Hill
University Press of Florida
£93 ● HB



This collection of eight essays covers a wide range of subjects, each one viewed through the lens of the Space Race and the impact that Project Apollo has had on wider society. The contributors consider both the immediate and long-term effects of such an intense and prolonged national effort. Each of the chosen authors comes from a different discipline and each takes a look at how Apollo has affected their own particular area of interest.

After an introduction and acknowledgements, we find chapters on the audacity of the plan itself, a look at the hidden chemistry, and how Wernher von Braun sought publicity for space exploration. Then we move on to chapters on the effects Apollo had on civil rights debates and protests, the disproportionately large role played by immigrants in the programme and how women were included, excluded and portrayed in commercial advertising influenced by the Space Age.

The final two essays of *After Apollo* cover the IMAX films made about Apollo and the emerging field of space tourism. Each chapter is fully referenced and an extensive index and profile of each author is included.

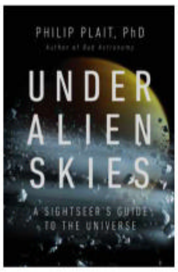
Although the Apollo programme has fascinated many of us for years, it's refreshing to see the subject from different perspectives. Issues such as the boycott by African-American workers of the federal holiday announced by President Nixon to celebrate the return of Apollo 11 are rarely mentioned in today's discussions of Apollo. Depending on your interests, some chapters will appeal more than others, but each provides a different outlook on "the inspired lunacy of Apollo". ★★★★☆

***Mark Bowyer** is a writer specialising in human spaceflight*

Under Alien Skies

COSMIC TOUR

Philip Plait
WW Norton
£23.99 ● HB



All astronomers, whether they be professional or amateur, must live with the sad reality that our perception of the Universe is confined to one tiny corner of space. Perhaps it's because of this that the question of what things would look like from other points of view remains a subject of perennial fantasy and fascination. For instance, what would it really be like to walk on another world in our Solar System? Or, what would you see if you could view a distant star from an orbiting exoplanet?

This other point of view forms the focus for Phil Plait's marvellous book *Under Alien Skies*, a journey across the space from our cosmic doorstep to some of the most extreme environments in the Universe.

Perhaps better known as the internet's Bad Astronomer, Plait has a well-deserved reputation as a lively and accurate communicator of cutting-edge science, and this universal tour guide offers a great opportunity for him to flex his explanatory muscles. Images in the book are largely confined to a well-chosen plate section, leaving the text to conjure up a human's-eye-view of environments ranging from the surface of Earth's Moon to the interior of a star-forming nebula.

While the book's central conceit treats the reader as a sci-fi 'cosmic tourist' in an unspecified future, Plait wisely knows when to break character and concentrate on clearly explaining how we know what we know at present. Along the way, there are plenty of answers to thought-provoking questions, such as what Pluto's family of moons look like from its surface, and what the calendar is like for a planet orbiting a binary star. All in all, then, this is a hugely enjoyable read that brings a new perspective to the cosmos.
★★★★★

***Giles Sparrow** is a science writer and a fellow of the Royal Astronomical Society*

Ezzy Pearson rounds up the latest astronomical accessories

GEAR

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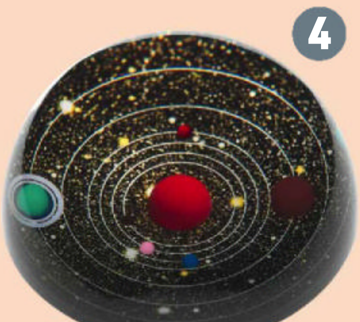


4

5

6

1 Vixen widefield 2.1x42H binoculars

Price £329 • **Supplier** Telescope House
www.telescopehouse.com

These 2.1x magnification binoculars enhance your night-sky observing while maintaining a wide field of view, granting an impressive view of stars in the Milky Way and the constellations.

2 Kendrick transparent Bahtinov masks

Price from £35 • **Supplier** The Widescreen Centre
www.widescreen-centre.co.uk

Focus your astrophotography setup even faster with a transparent mask that produces much larger diffraction spikes than its opaque counterparts. Sizes range from 50mm to 14 inches to ensure a snug fit.

3 Dual-Palm rechargeable hand warmers

Price £34.99 • **Supplier** Ellis Brigham
www.ellis-brigham.com

Warm your fingers throughout the night with this pair of rechargeable hand warmers. You can either use them separately or magnetically click them together to create a single heat source. Each warmer has three heat settings and works for 6–9 hours.

4 Planetary paperweight

Price £40 • **Supplier** Royal Museums Greenwich
https://shop.rmg.co.uk

Hold the world in your hands – and all the other planets too – with this solid glass paperweight. It has a felt base to protect your table and with its presentation box makes a perfect gift for space enthusiasts.

5 Sega Homestar Matataki Blue planetarium

Price £154 • **Supplier** Astroshop.eu
www.astroshop.eu

Enjoy a starry sky from your sofa! This latest model comes with a special effects plate to make your stars twinkle. Inbuilt speakers play natural soundscapes and there's a timer to turn the light off if you fall asleep.

6 Sky-Watcher 2-inch erecting prism 45˚

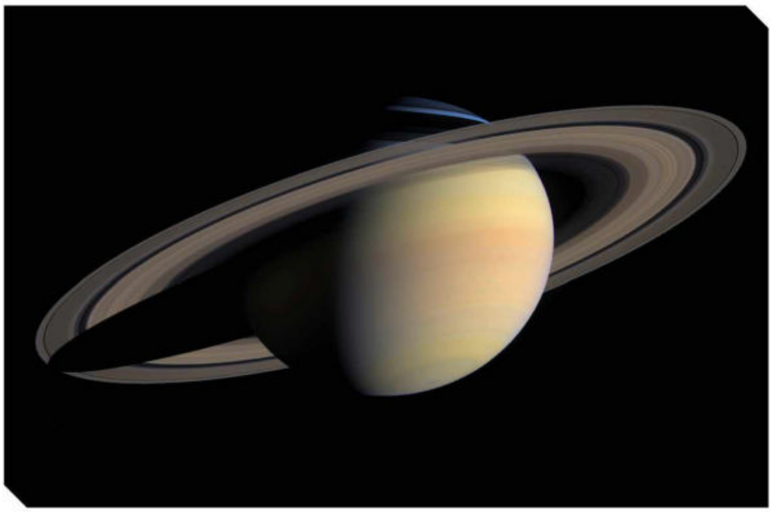
Price £99 • **Supplier** Harrison Telescopes
www.harrisontelescopes.co.uk

Designed to give a comfortable viewing angle during daytime observations, this prism bends your scope's light path through 45˚. Made for 2-inch focusers, it can be used with 2- or 1.25-inch eyepieces with adaptors.

Anita Chandran interviews Dr James O'Donoghue

Q&A WITH A PLANETARY EXPERT

Researchers have made a startling discovery: Saturn's iconic rings may be disappearing, as the material within them slowly rains down on the planet



▲ Enjoy them while they last, which is likely to be several hundred million years, as Saturn is gradually shedding its iconic dust-and-ice rings

NASA/JPL/SPACE SCIENCE INSTITUTE

Can you tell us a bit about our planetary neighbour Saturn?
Saturn is a 'gas giant planet' nearly 10 times wider than Earth and made mostly of hydrogen. It has a ring system and rotates fast; a day on Saturn is just 10 and a half hours. It's a very interesting world because of its rings, which have become a symbol of the Solar System – when you look at illustrations that symbolise science at a Science Festival, you'll almost always see images of Saturn.

What are Saturn's rings made of?
They're made of ice that is nearly completely composed of water, with a little bit of dust that has been picked up over aeons. The ice is made of fragments, from dust-sized particles all the way up to bus-sized pieces, which independently orbit Saturn, arranged so that the rings are only several metres in thickness overall. The fragments are aligned into countless thin tracks, with the inside tracks orbiting the planet faster than the outside tracks.

How old do scientists think Saturn's rings are?
There's a huge schism in the field about how old the rings are. They look very young, as though they were formed hundreds of million of years ago. But the debate suggests that they could have instead formed around four billion years ago when the Solar System was a much more active place, as the kinds of giant collisions that form rings were much more common back then. On the other hand, Saturn's rings look really clean, almost 99 per cent pure water, and that isn't feasible if they're billions of years old.

Are Saturn's rings a permanent feature?
We think they're falling into the planet. We found that there must be a lot of material flowing into Saturn at mid-latitudes, and inferred that the material is water, since that's what the rings are made of, but it's likely some of the material is tiny pieces of silicate rock.

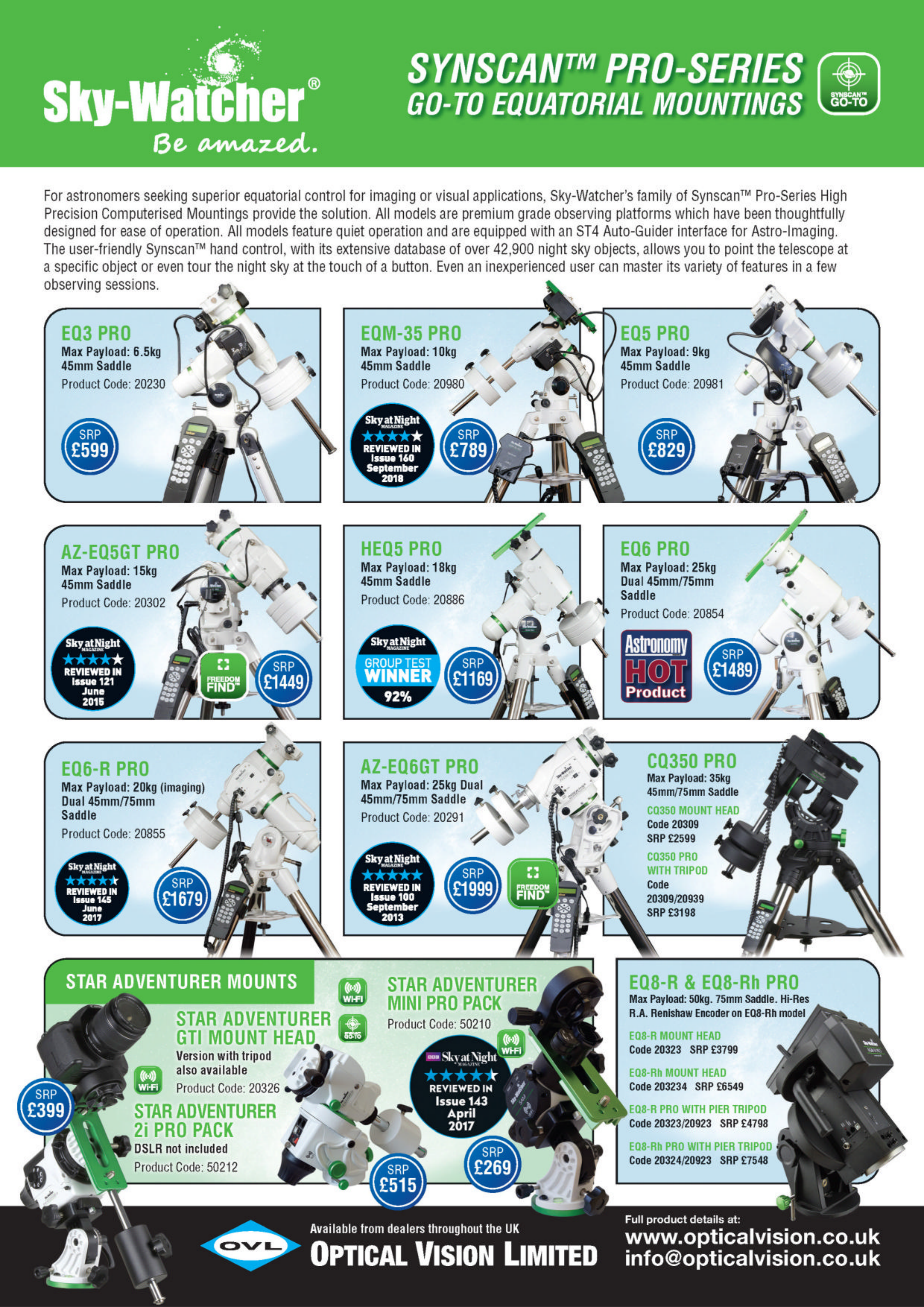
We can see this as there is a depletion in the density (or number) of electrons in Saturn's atmosphere – there are huge bites missing where you don't expect them. But why? It's a complicated chain of chemical reactions but, essentially, the neutral water neutralises charged electrons, reducing the electron density. This 'ring rain' is having a big impact on Saturn's atmosphere. In 2017, the Cassini spacecraft found about 10 times more material flowing in at the equator than we found at mid-latitudes.

James O'Donoghue is a planetary scientist, astronomer and science communicator working at the Japanese Space Agency. His research follows the upper atmospheres of giant planets

How long do we think Saturn's rings will last?
We know the rate at which the rings are falling in and we know their current mass. Extrapolating that into the future, we predict the rings could last 100 million to 1.1 billion years. But most likely it's in the order of hundreds of millions of years. We still need a lot more evidence – studies from the last few weeks showed it could even be 100 million years or less. I think we can say we're lucky to be alive at a time when we get to see Saturn's ring system at all.

What is your team hoping to investigate about Saturn next?
We want to see how ring rain varies with the seasons. As Saturn progresses through its year, the rings become more or less inclined towards the Sun, exposing the rings to more or less sunlight. We think ring rain should flow faster when the rings are highly inclined to the Sun, since sunlight charges the ring grains, which allows them to ride into Saturn via the planet's magnetic field.

Each of Saturn's seasons lasts nine years. In 2025, the rings will be edge-on to the Sun and seven years after, they'll be totally exposed. We hope to take measurements over the next decade to track the rate of ring rain over time and multiply it by four to understand what happens in a year at Saturn (29 Earth years). We also want to use the James Webb Space Telescope's ridiculously high sensitivity to see if we can get a more precise estimate of the ring rain's influx, which will help us to be more precise about the rings' current erosion rate and future lifetime.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Be amazed.
SYNSCAN™ PRO-SERIES
GO-TO EQUATORIAL MOUNTINGS
SYNSCAN™ GO-TO
For astronomers seeking superior equatorial control for imaging or visual applications, Sky-Watcher's family of Synscan™ Pro-Series High Precision Computerised Mountings provide the solution. All models are premium grade observing platforms which have been thoughtfully designed for ease of operation. All models feature quiet operation and are equipped with an ST4 Auto-Guider interface for Astro-Imaging. The user-friendly Synscan™ hand control, with its extensive database of over 42,900 night sky objects, allows you to point the telescope at a specific object or even tour the night sky at the touch of a button. Even an inexperienced user can master its variety of features in a few observing sessions.
EQ3 PRO
Max Payload: 6.5kg
45mm Saddle
Product Code: 20230
SRP £599
EQM-35 PRO
Max Payload: 10kg
45mm Saddle
Product Code: 20980
Sky at Night MAGAZINE ★★★★★ REVIEWED IN Issue 160 September 2018
SRP £789
EQ5 PRO
Max Payload: 9kg
45mm Saddle
Product Code: 20981
SRP £829
AZ-EQ5GT PRO
Max Payload: 15kg
45mm Saddle
Product Code: 20302
Sky at Night MAGAZINE ★★★★★ REVIEWED IN Issue 121 June 2015
FREEDOM FIND™
SRP £1449
HEQ5 PRO
Max Payload: 18kg
45mm Saddle
Product Code: 20886
Sky at Night MAGAZINE GROUP TEST WINNER 92%
SRP £1169
EQ6 PRO
Max Payload: 25kg
Dual 45mm/75mm
Saddle
Product Code: 20854
Astronomy HOT Product
SRP £1489
EQ6-R PRO
Max Payload: 20kg (imaging)
Dual 45mm/75mm
Saddle
Product Code: 20855
Sky at Night MAGAZINE ★★★★★ REVIEWED IN Issue 145 June 2017
SRP £1679
AZ-EQ6GT PRO
Max Payload: 25kg Dual
45mm/75mm Saddle
Product Code: 20291
Sky at Night MAGAZINE ★★★★★ REVIEWED IN Issue 100 September 2013
SRP £1999
FREEDOM FIND™
CQ350 PRO
Max Payload: 35kg
45mm/75mm Saddle
CQ350 MOUNT HEAD
Code 20309
SRP £2599
CQ350 PRO WITH TRIPOD
Code 20309/20939
SRP £3198
STAR ADVENTURER MOUNTS
STAR ADVENTURER GTI MOUNT HEAD
Version with tripod also available
Product Code: 20326
Wi-Fi
GO-TO
SRP £399
STAR ADVENTURER 2i PRO PACK
DSLR not included
Product Code: 50212
SRP £515
STAR ADVENTURER MINI PRO PACK
Product Code: 50210
Wi-Fi
BBC Sky at Night MAGAZINE ★★★★★ REVIEWED IN Issue 143 April 2017
SRP £269
EQ8-R & EQ8-Rh PRO
Max Payload: 50kg. 75mm Saddle. Hi-Res R.A. Renishaw Encoder on EQ8-Rh model
EQ8-R MOUNT HEAD
Code 20323 SRP £3799
EQ8-Rh MOUNT HEAD
Code 203234 SRP £6549
EQ8-R PRO WITH PIER TRIPOD
Code 20323/20923 SRP £4798
EQ8-Rh PRO WITH PIER TRIPOD
Code 20324/20923 SRP £7548
OVL
Available from dealers throughout the UK
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Full product details at:
www.opticalvision.co.uk
info@opticalvision.co.uk

THE SOUTHERN HEMISPHERE

With Glenn Dawes

Catch the Super Blue Moon, take a tour of Aquila and welcome Venus back to the morning skies

When to use this chart

1 Aug at 00:00 AEST (14:00 UT)
15 Aug at 23:00 AEST (13:00 UT)
31 Aug at 22:00 AEST (12:00 UT)

The chart accurately matches the sky on the dates and times shown for Sydney, Australia. The sky is different at other times as the stars crossing it set four minutes earlier each night.

AUGUST HIGHLIGHTS

We've all heard the phrase 'once in a Blue Moon'. This name is given to a second full Moon in any month. It's not so rare, happening every two to three years. August has a Blue Moon, with both full Moons also being supermoons. A loose definition would be when the Moon is full within roughly one day of being closest to Earth (perihelion). This isn't so infrequent, happening around four times a year. Both events occurring together, well... it makes good trivia, if nothing else!

STARS AND CONSTELLATIONS

The Milky Way's centre lies in the direction of the spout star of Sagittarius's Teapot, hidden behind the dark nebulae which surround our Galactic equator. A dark silhouette gives us the 'pipe nebulae', but the bright clearings in this veil also create Sagittarius's Large and Small Star Clouds. The 'large' is best described as a cloud of steam rising from the spout. The 'small' is further north, appearing as a small island (among others) in this river of darkness.

THE PLANETS

Saturn reaches opposition, arriving around sunset and visible all night. Neptune follows about 2 hours later, rising around 20:00 mid-month. Mars and Mercury travel together low in the early western evening sky before Mercury drops away into the twilight towards solar conjunction next month. Jupiter and Uranus appear around midnight with both transiting (due north) just before sunrise. Rising out of the dawn glow, Venus makes its return to the morning sky this month.

DEEP-SKY OBJECTS

This month, a trip to Aquila the Eagle. Starting at Altair (Alpha (α) Aquilae), move 12° west-northwest and find third-magnitude Zeta (ζ) Aquilae. Travelling a further 1.5° west brings you to the double star 11 Aquilae (RA 18h 59.1m, dec. +13° 37'). A telescope shows this colourful pair has components of +5.3 and +9.0 magnitude which are yellow and blue respectively, separated by a comfortable 19 arcseconds.

As Aquila straddles the Milky Way, star-rich regions are abundant. One contains mag. +6.6 open cluster NGC 6709 (RA 18h 51.3m, dec. +10° 19'), 4° southwest of 11 Aquilae. This contains 60 or so stars from ninth to 11th magnitude, visible as a hazy patch through binoculars. Arranged in a triangular shape about 0.2° across, the stars form lines with a distinctive pair of ninth-magnitude yellow and blue stars on the western edge.

Chart key

GALAXY
OPEN CLUSTER
GLOBULAR CLUSTER
PLANETARY NEBULA
DIFFUSE NEBULOSITY
DOUBLE STAR
VARIABLE STAR
COMET TRACK
ASTEROID TRACK
METEOR RADIANT
QUASAR
PLANET
STAR BRIGHTNESS:
MAG. 0 & BRIGHTER
MAG. +1
MAG. +2
MAG. +3
MAG. +4 & FAINTER

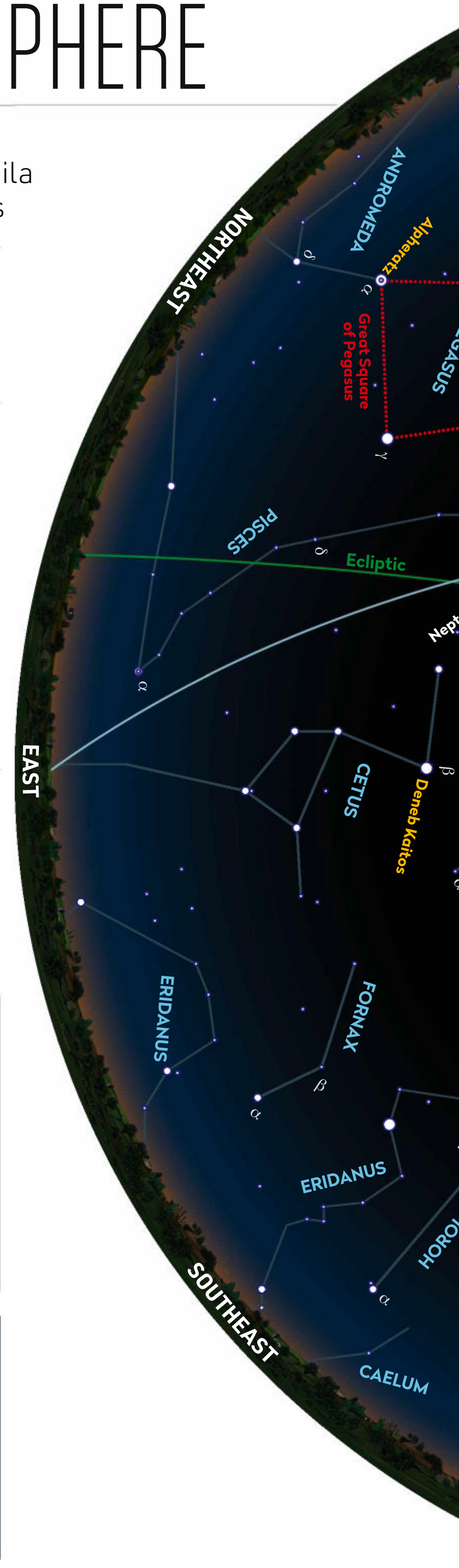
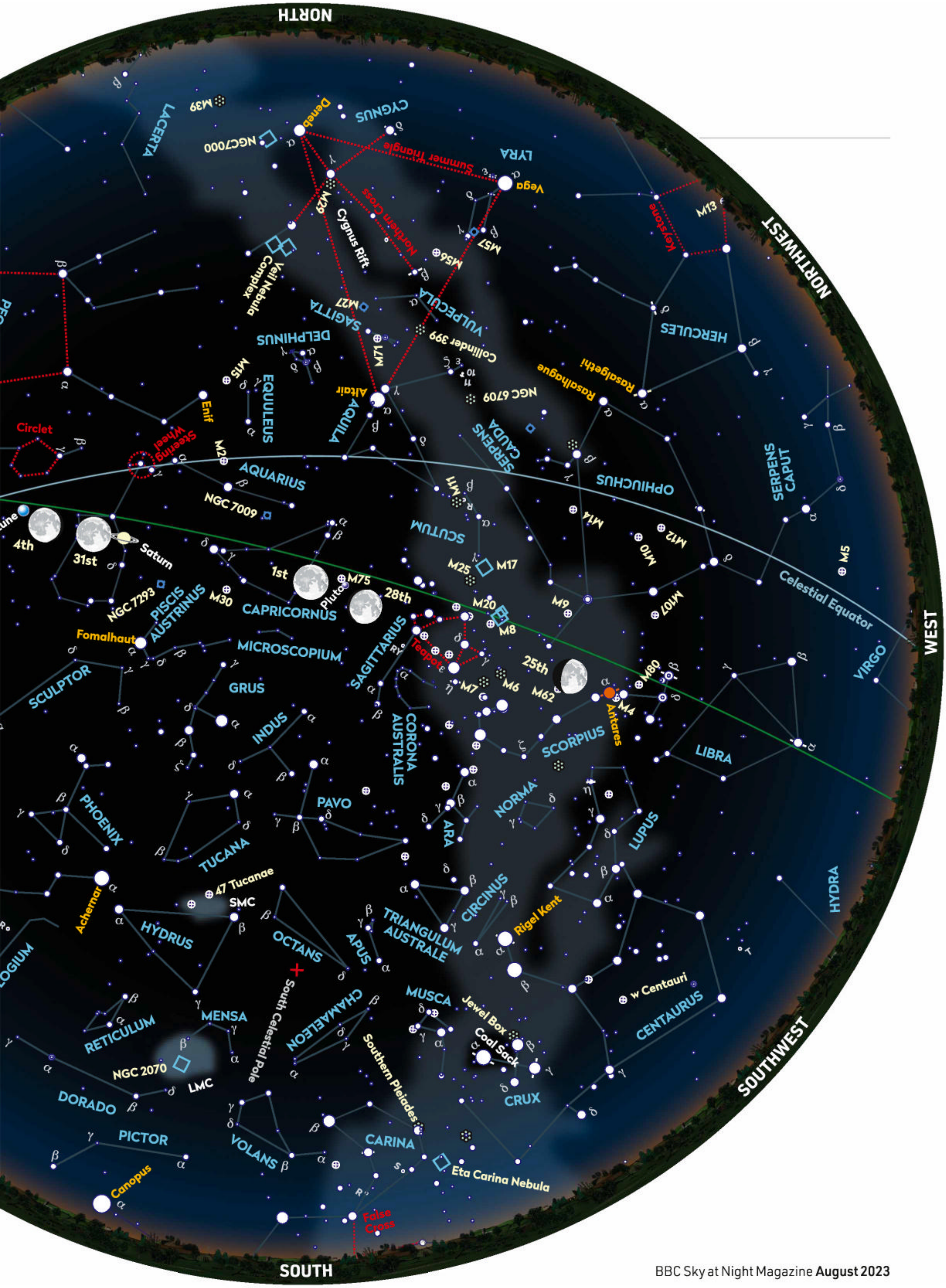


CHART: PETE LAWRENCE


NORTH
NORTHWEST
WEST
SOUTHWEST
SOUTH
CYGNUS
Deneb
LYRA
Vega
Summer Triangle
Northern Cross
Cygnus Rift
LACERTA
M39
NGC7000
M29
M57
M56
M13
Keystone
HERCULES
Veil Nebula Complex
M27
SAGITTA
VULPECULA
DELPHINUS
M71
Collinder 399
Rasalgethi
Rasalhague
M15
EQUULEUS
Altair
AQUILA
NGC 6709
SERPENS CAUDA
Enif
Circlet
Steering Wheel
M2
AQUARIUS
NGC 7009
M11
OPHIUCHUS
SERPENS CAPUT
M14
SCUTUM
M12
M10
M5
Celestial Equator
4th
31st
Saturn
1st
M75
Pluto
28th
M25
M17
NGC 7293
PISCIS AUSTRINUS
M30
CAPRICORNUS
M20
M8
M9
M107
Fomalhaut
MICROSCOPIUM
SAGITTARIUS
Teapot
25th
M80
M7
M6
M62
M4
Antares
VIRGO
SCULPTOR
GRUS
INDUS
CORONA AUSTRALIS
SCORPIUS
LIBRA
PHOENIX
PAVO
NORMA
ARA
LUPUS
TUCANA
47 Tucanae
SMC
Achernar
HYDRUS
OCTANS
APUS
TRIANGULUM AUSTRALE
CIRCINUS
Rigel Kent
HYDRA
South Celestial Pole
MUSCA
Jewel Box
Coal Sack
ω Centauri
CENTAURUS
MENSA
RETICULUM
CHAMAELEON
Southern Pleiades
CRUX
NGC 2070
LMC
DORADO
PICTOR
VOLANS
CARINA
Eta Carina Nebula
Canopus
False Cross